EXECUTIVE SUMMARY

Pearl Harbor is a major geologic feature of the island of Oahu and the receiving waters for several watersheds of the most populated island in the Hawaiian archipelago. The springs, streams, and tidally influenced waters combine to provide a variety of wetlands and wetland functions. Over the past 150 years, a dramatic population increase has resulted in development over most of the surrounding areas and alteration of land use and drainage patterns. This in turn has changed the quantity and characteristics of the wetlands presently existing in the region.

As part of the Pearl Harbor Integrated Natural Resources Management Plan, the Pacific Division, Naval Facilities Engineering Command has tasked the U.S. Army Corps of Engineers Honolulu District to delineate the wetlands of Pearl Harbor on specific U.S. Navy installations. The delineations were performed in accordance with the Corps of Engineers 1987 Wetland Delineation Manual and were certified for regulatory purposes by the Corps Honolulu District for five years. This report contains the documentation which went into the delineation process.

In addition to the delineations, reconnaissance level wetland mapping was accomplished for surrounding areas including wetlands in areas not owned by the U.S. Navy. The mapping was performed to get an estimate of the total quantity of wetlands in the Pearl Harbor area to determine the relative scarceness or abundance of these special aquatic sites. The reconnaissance mapping will give the reader an idea of the location and size of the wetlands but does not have detailed data sheets and is not certified for regulatory permit actions.

Wetlands are dynamic in nature and their characteristics and size vary with changes in land use, hydrology patterns and other natural and human actions. This report and its contents are a snapshot of the wetlands that will surely change over time. It is intended that the research, mapping, and database that has been accomplished for this effort be put in a format that can be used for future updates or for individual wetlands. Geographic Information Systems (GIS), Computer Aided Drafting and Design (CADD), and Global Positioning System (GPS) techniques were used to provide a layer of information of present wetland conditions and forms a basis for collecting comparative data in the future.

The digital mapping was accomplished using Intergraph's MicroStation SE and IRAS/C software connected to a MicroSoft Access database. Both the digital wetland map and database are included in a CD that is part of this report. Other resources such as historical maps, previous wetland mapping efforts, and related permit actions have been combined into an ArcView project which is also included in the CD. Text documents were scanned in Adobe Acrobat PDF format. A set of foldout maps showing the wetland delineations are also a part of this report.

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Chapter 1 - Introduction

1.1 Study Purpose

The purpose of this project was to map wetlands in the Pearl Harbor area and to perform wetland delineations at Ford Island, Halawa Stream, McGrew Point, Pearl City Peninsula, Naval Magazine Lualualei West Loch Branch (including Waipio Peninsula), Iroquois Point Naval Housing Area, and Puuloa Rifle Range Annex Camp Smith. In June 1998, the Corps and the Navy met several times to discuss the scope of work. Based on the meetings, it was determined that the objectives of the project are to: (1) provide certified delineations of wetlands on Naval properties; (2) provide a digital map and to develop and populate a wetland database for use with the Navy's GIS; and (3) to perform reconnaissance level mapping to obtain an estimate on the approximate aerial extent of wetlands surrounding Pearl Harbor.

Digital maps of Pearl Harbor's wetlands have been prepared using CADD software to complement existing digital data. The digital maps are compliant with Tri-Service Spatial Data Standards format to allow the greatest possible usage through CADD and/or GIS formats. An MS-Access database contains attribute information on the wetlands.

In addition to the MicroStation and MS-Access files, an ArcView project was created to demonstrate linkages with other digital information such as the data sheets, photographs, permit documents, and other reference material. The scripts developed are included in the project CD and are not encrypted in order to allow the project to be refined and adapted for future needs.

Wetland delineations and reconnaissance wetland maps are the two main products provided. The delineation map is certified by the Corps' regulatory office and sufficient for regulatory purposes. (See Appendix A for certification letter) The reconnaissance level mapping does not have sufficient documentation to warrant certification but locates and quantifies areas highly likely to be considered wetlands. The development of these maps are discussed in Chapter 2 of this report.

1.2 Wetland Functions and Values

In the past, wetlands were called swamps and treated accordingly. People had visions of mosquitoes and considered the swamps as convenient places for dumps and places to build facilities that were unwanted in their neighborhoods. Kawai Nui Swamp on Oahu was used as a sewage disposal area and partially filled with construction debris and other industrial, commercial, and personal waste. Waikiki and Ala Moana were formerly marshes that were dredged and filled to reclaim land. All three of these areas functioned as sediment basins, stormwater retention areas, nurseries for fish, and prime nesting areas for currently endangered waterbirds. In the Pearl Harbor area, Kalauao, Makalapa Crater and Pearl City Peninsula wetlands were filled for similar reasons.

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Wetlands can be productive natural ecosystems for fish and wildlife. In the main Hawaiian islands, there are four endangered waterbirds: the *Koloa maoli* or Hawaiian Duck *(Anas wyvilliana);* the Hawaiian Stilt *(Himantopus mexicanus knudseni);* the Hawaiian moorhen *(Gallinula chloropus sandvicensis);* and the Hawaiian Coot *(Fulica alai).* The *Hawaiian Waterbird Recovery Plan* designated portions of Pearl Harbor as both primary and secondary habitat areas for these endangered waterbirds. Primary habitat provide all of the requirements for completion of the annual life cycle for a significant number of birds in a region. Secondary habitat are of lesser importance and support a small number of birds.

The wetlands of Pearl Harbor provide a variety of habitat for waterbirds including mudflats, shallow ponds, and coastal wetlands. The U.S. Fish and Wildlife Service has established the Pearl Harbor National Wildlife Refuge (PHNWR) at two locations. The Honouliuli unit of the PHNWR is located near the West Loch shoreline park while the Waiawa unit of the PHNWR is located on the west side of the Pearl City Peninsula.

The wetlands along the coastline, streams and ponds also provide habitat for fish and crustaceans which are a part of the food chain. Mullet, barracuda, and aholehole use the brackish water areas during their life cycle. Mudflats provide feeding and resting areas for the endangered Hawaiian Stilt.

In addition to providing wildlife habitat, wetlands slow water velocities and help to trap sediments and pollutants before they can enter Pearl Harbor. Wetlands can break down the pollutants and reduce the sediment and pollutant load to improve water quality in coastal areas. Wetland plants absorb nutrients and help to purify the water much like a kidney. In some areas of the world, wetlands are created to help treat sewage and stormwater runoff.

Another function of wetlands is to absorb excess water during floods which is then slowly released. This helps to reduce the peak discharges caused by floods. Wetland vegetation also protects shorelines from erosion by absorbing wave energy. However, aggressive vegetation such as mangroves can also lead to unwanted land building, obstruction of the view plane, and worsening drainage conditions. Several of the streams in the Pearl Harbor area are choked with mangroves and may experience some of these negative impacts.

In the past, Pearl Harbors wetlands were used for fishponds and agricultural purposes. Some of these wetlands are being actively farmed for watercress, lotus root, and taro, particularly in the Waiawa area.

The aesthetic values and recreational values provided by wetlands for fishing, hiking and wildlife watching are also important. As Oahu grows more urban, green space and wildlife become increasingly harder to find.

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In recent years, society has come to realize the values and functions of wetlands. Filling small wetlands may seem insignificant especially when looking only at the adjacent environment. However, filling a number of small wetlands can cause a cumulative effect and irretrievable damage to these special aquatic sites.

1.3 Wetland Definition

Since 1899, the Corps has been regulating the nation's navigable waters under the authority of the Rivers and Harbors Act. In 1972, the Clean Water Act was enacted. In 1975, the Corps adopted new regulations that added nonavigable waters including wetlands, into the definition of waters of the U.S. Of particular interest is Section 404 of the act which requires a permit to be obtained from the Corps of Engineers before dredge or filled materials can be discharged into waters of the U.S. including wetlands.

The Corps has come out with guidance on how wetlands are defined. The Corps developed a wetland delineation manual in 1987. The manual was rewritten in 1989 and this version was used for several years. Later, the Corps signed a Memorandum of Agreement (MOA) with the Natural Resource Conservation Service, the U.S. Environmental Protection Agency, and the U.S. Fish and Wildlife Service (USFWS) to discontinue using the 1989 manual and to use the 1987 Wetland Delineation Manual instead.

Corps of Engineers and U.S. Environmental Protection Agency Wetland Definition

"Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under natural circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas."

COE definition codified at 33 CFR 328.3
USEPA definition codified at 40 CFR 230.3

Other entities such as the USFWS and the State of Hawaii have a broader wetland definition. In the 1987 manual, a wetland must have evidence of hydric soil, water, and vegetation indicators. In contrast, the USFWS only requires the presence of one of these attributes.

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Chapter 2 - Wetland Mapping Process

2.1 Literature Search

2.1.1 Previous Wetland Documentation Efforts

Wetland mapping for a large area such as Pearl Harbor is made more efficient by researching previous efforts. In this way, efforts can be focused on areas that are believed to have the highest potential for wetlands. Wetlands are dynamic and change over time so history and land use is important in the development and evolution of these special aquatic sites.

One of the earlier references is a map entitled *Hawaii Territory Survey, Oahu, Hawaiian Islands*, dated 1902. The map measures 27" by 32" at a scale of approximately 0.7 inches per mile and was developed for the Governor's Annual Report illustrating conditions as of June 30, 1906. Federal lands, plantations, forest reserves, fishponds, agricultural features, and wetlands (taro and rice) are noted on this map. While the map provides a good perspective of land use and major wetlands of the era, it was at too coarse a scale to delineate individual wetlands in the present mapping project.

Another early source of information are the Corps of Engineers' 1913 maps of the island of Oahu. The maps were developed from field surveys undertaken during 1909-1913 to prepare a plan for defending the island of Oahu from attack. At the time, this had been the most detailed mapping for an entire Hawaiian island. Thirteen sheets make up the island of Oahu and provides topological features such as contours, streams, fishponds, and taro lo'i. Pearl Harbor is on two sheets and includes features such as taro lo'i, salt ponds, and military installations.

In addition to these early references, there are numerous site and site surveys for specific wetlands such as Kawai Nui Marsh, the Heeia mangrove forest, mangroves, fishponds, bogs, and historical and cultural references. Particularly helpful documents are Apple and Kikuchi's *Ancient Hawaii Shore Zone Fishponds* (1975) and Sterling and Summer's *Sites of Oahu* (1978). The filling and conversion of fishponds, taro lo'i and rice fields has impacted the wetland characteristics of Pearl Harbor. Introduction of alien species such as mangrove, tilapia, and mongoose has also altered the biological makeup and usage of wetland habitat.

In the early 1970's, the Corps of Engineers regulatory permit jurisdiction was increased to include Section 404 of the Clean Water Act. This act expanded the Corps' jurisdiction from navigable waters to include wetlands, streams and inland waterways. To help implement this portion of the permit program, the first comprehensive wetland inventory for the State of Hawaii was developed with Hall and Elliott's *Wetlands and Wetland Vegetation of Hawaii* (1977). This report focused on major wetlands and included 78 sites on the islands of Kauai, Oahu, Molokai, Maui, and Hawaii. Pearl Harbor was split into three sites comprising 15 wetlands.

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The maps are based on the 1:24,000 USGS quadrangle maps, U-2 false infrared imagery and 1:6,000 panchromatic aerial photographs. This inventory was prepared prior to the development of a wetland delineation manual and prior to the establishment of a wetland plant list for Hawaii. Given the available technology and knowledge of wetlands, this document provides excellent information and pioneered the way for wetland mapping in Hawaii.

An Ornithological Survey of Hawaii Wetlands (1977) was written by Ahuimanu Productions for the Corps of Engineers to comply with the Fish and Wildlife Coordination Act and Endangered Species Act during evaluation of Department of the Army permit applications. The two-volume report included excellent descriptions of the waterbirds, wetland habitat, and copies of aerial photographs. A companion reference to the Hall and Elliott report, the same seventy-eight sites were visited. Comparing the status of the wetlands and waterbird species at the time with the conditions and land uses of the present shows how manmade changes have impacted wetlands and wetland habitat.

The National Wetland Inventory (NWI) was developed by the U.S. Fish and Wildlife Service using the Cowardin System. The NWI covers the nation including the main Hawaiian Islands. The maps were originally done in the early 1980's using pen and ink on an overlay of the USGS 1:24,000 quad sheets. The maps were later digitized by Geographic Decision Systems International and are available in an ArcView shape file through the State of Hawaii. Although the scale is rather coarse and many of the wetlands have changed, the NWI effort and the Hall and Elliott study are the only sets of wetland maps that offer coverage over most of the Hawaiian Islands.

In 1999, the NWI operational team in St. Petersburg, Florida, updated the NWI maps for Naval installations in Hawaii using 1:62,500 color infrared photographs. The digitizing techniques have improved and more data is available which has resulted in much better quality maps than the previous effort. It is important to note that the wetland definition used for the NWI is not the same as the Corps 1987 wetland delineation manual. While three parameters (soil, water, vegetation) are required for an area to be considered a wetland by the Corps, only one parameter is required under the NWI criteria. Thus the NWI maps include areas that are not jurisdictional wetlands. Appendix F contains the maps and report for the 1999 NWI study.

The Environmental Center and Water Resources Research Center of the University of Hawaii at Manoa wrote a document entitled *Ecologically Sensitive Wetlands on O'ahu: Groundwater Protection Strategy of Hawaii*. Focusing on groundwater, this 1989 (draft) report consolidated much of the available environmental data and identified potential sources of groundwater pollutants. Unfortunately the only map provided in this document is an 8.5 by 11-inch plan of Oahu. However, the identification of water sources and consolidation of species lists were valuable to the present wetland mapping effort.

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Finally, Corps permit records involving wetlands were reviewed. There have been over 200 permit actions in the Pearl Harbor area but only a limited number involve wetlands. Permit files often contain documents such as Environmental Impact Statements, botanical surveys, and topographical information which are useful in identifying and researching wetlands. Pertinent actions were recorded as points on an ArcView shapefile. Excerpts from the permit documents were scanned and indexed in Adobe Acrobat format and hotlinked to the shapefile. Both the shapefile and the Acrobat files are included in the CD for this project as are several environmental documents for wetland related projects. It should be noted that the regulatory permit program has changed tremendously since the first permit was issued in 1903. Due to changes in laws and guidance, permit decisions in the past are different than what would occur today (eg. Excavation rule, changes in wetland delineation manual, etc.). Thus, users of this data are cautioned not to use permit actions in the past as a basis for current regulatory issues and that professional judgement needs to be exercised when using any information. It is much easier and safer to call the Corps Regulatory Branch (438-9258) to get a determination on permit requirements. Nonetheless, permit files contain important documents which are an integral part of the written history of the wetlands and former wetlands of Pearl Harbor.

2.2 Field Procedures

Prior to going into the field, a literature search (see previous section) was conducted to determine where wetlands would be expected to occur. Most of the data was digitally scanned and is available on the CD for this project. Available GIS data, which also included the U.S. Fish and Wildlife Service's National Wetland Inventory, were also used to identify potential wetland locations. Based on the information obtained, the entire installation was walked and identified areas were checked and/or delineated. This was followed by wetland delineations based on the Corps of Engineers 1987 Wetland Delineation Manual and subsequent mapping. Data sheets containing information on wetland soil, plant and hydrology indicators can be found in Appendix C.

The wetland mapping is based on a set of digital grayscale orthophotographs prepared by GeoInsight International and R.M. Towill Corporation. The resolution of the photographs was 20 cm per pixel. Originally provided in TIFF format, the drawings were converted into a format compatible with Intergraph's MicroStation and IRASC CADD software. Microstation's robust set of drawing tools made it much easier to use heads up digitizing of wetland boundaries. A database was generated from the Tri Service Spatial Data Standards in MS-Access format. As each wetland polygon was drawn, it was connected to the database using an ODBC connection.

It should be noted that no orthophotograph coverage was available for the non Navy properties in the western shoreline of West Loch. The Corps scanned an April 1997 aerial photograph by Air Survey Hawaii Inc. and did a rough registration and rectification of the image using ArcInfo. Since ground control points in the area were not available, the image was registered to points

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from the U.S. Geological Survey 1:24000 quadrangle maps, orthophotographs, and other GIS data. While the positional accuracy is rather coarse, it enables one to get a perspective of the extent of wetlands in this area at a very low cost.

In some cases, the tree canopy and grayscale colors made it difficult to map the wetlands using orthophotographs. A Trimble Pro XRS global positioning system (GPS) was used to map wetlands in these areas. The GPS data was differentially corrected to increase accuracy.

2.3 Digital Mapping

This report contains two main products: a reconnaissance wetland map and a wetland delineation map. Both wetland maps are provided in CADD and hardcopy formats. In the reconnaissance map, the Corps identified areas with a high potential for wetlands throughout Pearl Harbor (including areas outside of Navy jurisdiction) based on past delineations, wetland inventories, studies, and other available information. Approximately 70 percent ground truthing field work was performed for the reconnaissance wetland map. Delineation level data was not gathered nor was documentation prepared due to cost considerations. The reconnaissance level map can be used as a general guide to locate known wetlands and is sufficient for environmental planning documents. However, this map is not sufficient to be used as certified wetland delineations for permit applications due to the lack of data documentation.

In the delineation product, the Corps delineated wetlands at the following areas identified by the Navy: Makalapa Crater, Ford Island, Halawa Stream, McGrew Point, Pearl City Peninsula, Naval Magazine Lualualei West Loch Branch (including Waipio Peninsula), Iroquois Point Naval Housing Area, and Puuloa Rifle Range Annex Camp Smith. Naval properties were colored on a hardcopy map by the Navy and transmitted to the Corps. The hardcopy map was used to determine the boundaries of the areas to be delineated.

The mapping for both products were based primarily on ground investigations and digital orthophotographs of the Pearl Harbor area provided by the Navy. Global Positioning System and hardcopy aerial photography were also used to supplement the orthophotographs. One set of orthphotographs was prepared by GeoInsight International, Inc. and covered Ford Island, Makalapa Crater, and a portion of the shipyard out to Aiea Bay. The second set of orthophotographs was prepared by R.M. Towill Corporation and covered the area from Aiea Bay to Puuloa.

2.4 Database Conventions

The drawings follow the Tri Service Spatial Data Standards. Table 1 shows the structure for a database which will contain the information for each polygon.

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Table 1 - Data fields for Both Certified Wetlands and Reconnaissance Mapping	
Field	**Domain**
Loch	West Middle East
Segment	1. Puuloa Rifle Range to Iroquois Point Lagoon (Iroquois Housing Area) 2. Iroquois Point Lagoon to Honouliuli NWR (NAVMAG Lualualei - West Loch Branch) 3. Honoluliuli NWR to Waipahu Interm School Canal (West Loch Shoreline) 4. Waipahu Interm School Canal to Waipahu H.S. Channel (Waipio Peninsula) 5. Waipahu H.S. Channel to Pouhala Marsh (Middle Loch Shoreline) 6. Pouhala Marsh to Waimanu Stream (Pearl City Peninsula) 7. Waimanu Stream to West edge of Loko Paaiau Fishpond (East Loch Shoreline I) 8. West edge of Loko Paaiau Fishpond to East end of housing area (McGrew Point) 9. McGrew Point East boundary to North side of Halawa Stream (East Loch Shoreline II) 10. South side of Halawa Stream to South Avenue (Naval Supply Center/Shipyard) 11. Makalapa Crater 12. Ford Island
Wetland id	Unique identifier for each wetland polygon
Wetland name	Alphanumeric name of wetland based on the location (eg. Kalauao #12)
Wetland description	Brief descriptor of wetland
RAMS id	If applicable, Department of the Army permit(s) or application(s)
Wetland area	In the main table, area is expressed in square meters. Query is used to express area in acres. Hectare equals 10,000 square meters.
Wetland type	Broad classifications of (1) mangrove; (2) other coastal; (3) stream; (4) other fresh water.
Navy or NonNavy?	Used to distinguish whether wetland is primarily on Navy controlled property or not

The database provides a source for information such as area, vegetation, and delineators. Data for the fields in Table 2 would be added for areas mapped during the delineation phase. Please see metadata at Appendix D for more details on the database attributes.

The resulting products provide the location of known wetlands in the Pearl Harbor area. The map also provides planners with a quantitative estimate of the wetlands within the entire Pearl Harbor area. Overall wetland area is an important piece of information to compare and determine the significance of wetland impacts from a project.

Results of the reconnaissance survey should not be used for regulatory purposes as there is no final wetland jurisdictional delineation. However, if there are any actions which are adjacent or overlap with the wetland areas identified on the reconnaissance survey, it would indicate that wetlands may be present and that the Corps should be contacted for permit requirements.

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Table 2 – Added Data From Wetland Delineations	
Delineation?	Yes/No
Delineation date	Date that delineation was performed (if applicable).
Delineator	Three fields with complete first and last name (no abbreviations, separate table)
Primary wetland plants	Scientific names. (This will alert Planners of potential wetlands in areas where these plants occur. Separate domain table)
Installation	Used to group wetlands by the associated area and not necessarily by Naval activity. For example, wetlands at Waipio Peninsula are considered separately from wetlands at NAVMAG LLL, West Loch Branch

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CHAPTER 3 – WETLAND DESCRIPTIONS

3.0 Overview

3.0.1 Segments

Based on the scope of work for this contract, wetlands were to be delineated on discrete Navy properties in Pearl Harbor. In addition to delineations for U.S. Navy properties, reconnaissance level wetland mapping was accomplished for non naval properties in West Loch, Waipahu, and Pearl City to provide a regional context for the wetland quantity, quality, and environment in the Pearl Harbor Region. Based on the naval installations of interest, the area was broken into twelve segments as shown on Figure 1 and described below. A descriptive overview of wetlands on the U.S. Navy properties and non navy properties are provided in this section.

1. Puuloa Rifle Range to Iroquois Point Lagoon (Iroquois Housing Area)
2. Iroquois Point Lagoon to Honouliuli NWR (NAVMAG Lualualei - West Loch Branch)
3. Honoluliuli NWR to Waipahu Interm School Canal (West Loch Shoreline)
4. Waipahu Interm School Canal to Waipahu H.S. Channel (Waipio Peninsula)
5. Waipahu H.S. Channel to Waiawa Unit, Pearl Harbor National Wildlife Refuge (Middle Loch Shoreline)
6. Waiawa Unit, Pearl Harbor National Wildlife Refuge to Waimanu Stream (Pearl City Peninsula)
7. Waimanu Stream to West edge of Loko Paaiau Fishpond (East Loch Shoreline I)
8. West edge of Loko Paaiau Fishpond to East end of housing area (McGrew Point)
9. McGrew Point East boundary to North side of Halawa Stream (East Loch Shoreline II)
10. South side of Halawa Stream to South Avenue (Naval Supply Center/Shipyard)
11. Makalapa Crater
12. Ford Island

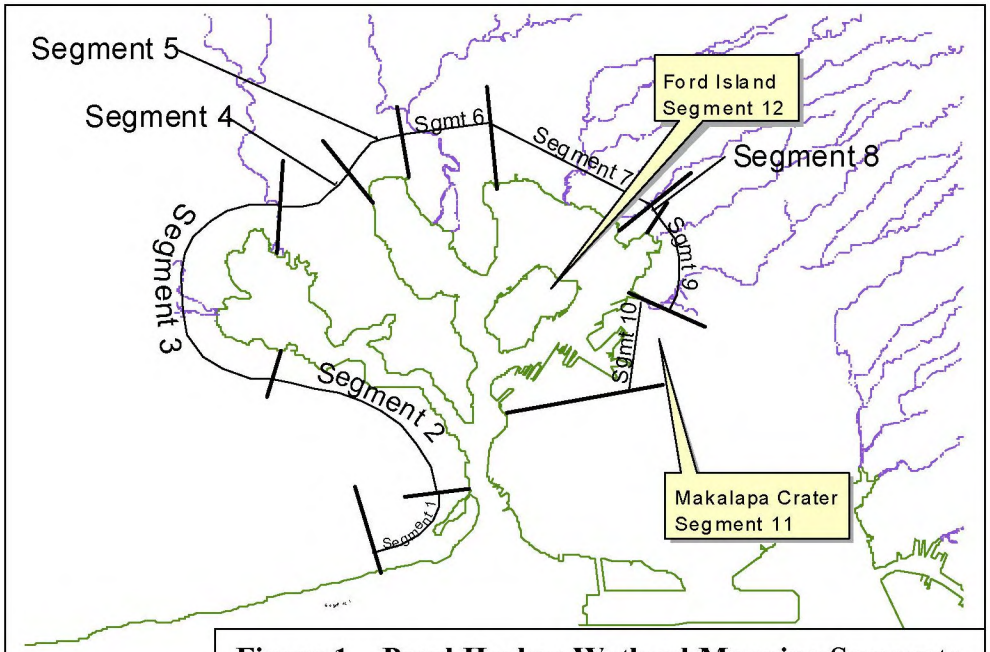

Figure 1 – Pearl Harbor Wetland Mapping Segments

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3.0.2 Geology of Pearl Harbor

Pearl Harbor is a drowned river system shaped by streams and by the rise and fall of the sea over a very long period of time. Figure 2 shows the geologic formation of Pearl Harbor. When the sea level was much higher, Pearl Harbor was a wide embayment. Coral reefs and oyster beds which were living underwater at the time were exposed on land when water levels receded. The sea level dropped at least 60 feet during the next glacial period as the ice caps on the poles grew. Subsequent melting and rebuilding of the ice caps contribute to the shape of the island. Geology is important in understanding why coralline material occurs at the surface in places like NAVMAG Lualualei West Loch Branch. At the same time, the erosion of surface features and the subsequent deposition of silt and mud in low lying areas contribute to the formation of hydric soil. There are very few wetlands towards the entrance channel as compared to areas closer to the drainage area termini.

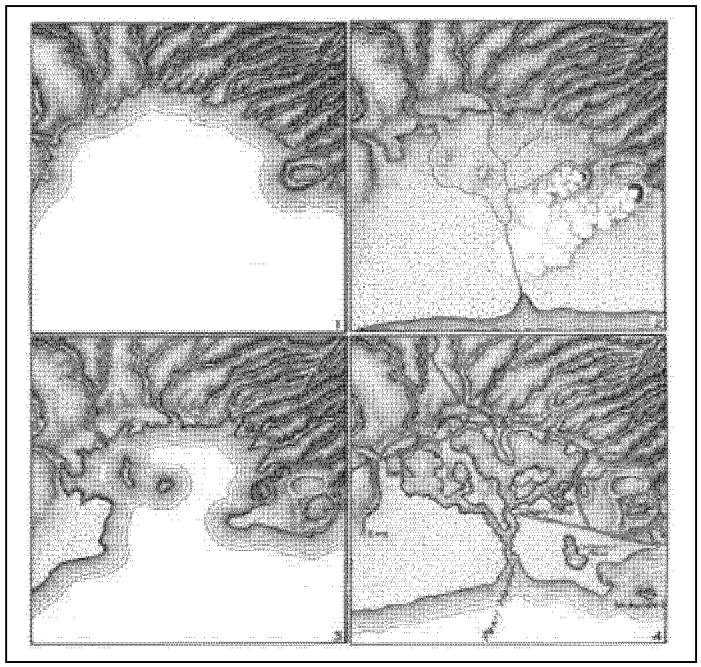

Figure 2 - Geologic history of Pearl Harbor
1. When the sea stood 95 feet higher. 2. When the sea stood about 60 feet lower. 3. When the sea stood 25 feet higher. 4. Present sea level. (Figs & description from Stearns, 1966)

3.0.3 Human Influences on the Wetlands of Pearl Harbor

Wetlands are influenced directly and indirectly by human uses. An example of direct change is dredging or filling to convert a wetland to an upland use. Indirect changes are offsite activities such as changes to drainage patterns or lowering the water table by pumping. To understand the history and changes to wetlands in an area, one must also recognize the changes from local land use and development. This section touches on some of these activities which have affected the wetlands of Pearl Harbor.

Prior to western contact, the early Hawaiians took advantage of water and surface features to grow taro, raise fish, and engage in subsistence activities. To raise taro, agricultural features such as wetland pond systems and *auwai* were built and maintained by native Hawaiians. Spring fed areas such as those found at Kalauao, Waimalu, and Waiau were known to be in taro production. Taro is still being cultivated in Waiawa, Waipahu, and West Loch.

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A PACNAVFACENCOM archaeologist provided us with a hardcopy map of the fishponds in the late 19th century as drawn by the State Historic Preservation Division. Over twenty fishponds/fishtraps have been documented in the Pearl Harbor area with the majority of them having being filled in either deliberately or naturally. Both inland and coastal fishponds existed within Pearl Harbor. A common type of fishpond used an external wall to close off an embayment or shoreline waters. They typically had one or more makaha (openings) at the seaward wall. The exterior walls create an environment sheltered from high wave energy. Over time and disuse, the openings and sometimes the walls deteriorated creating openings which allow mangrove seedlings to float in with the tide. The sheltered conditions provide a habitat conducive to mangrove growth and wetland conditions.

Maintaining these agricultural and aquacultural features required a lot of manpower which was obtained through the traditional poalima system. In this system and prior to the Mahele of 1848, a hierarchy of chiefs and stewards controlled the lands. Commoners provided the labor and a tax system was employed to distribute the products.

With the coming of the Great Mahele in 1848, the lands were distributed in fee ownership, and the poalima system was discontinued. Without the poalima system, it became difficult to keep the large fishponds and taro lo'i in production. Some of the agricultural features were continued while others fell into disuse. Most of the fishponds became the property of the Hawaiian government. Asian immigrants, brought in to work the sugar plantations, created a demand for rice. Some of the taro lo'i were converted into rice production as was the case at the Pearl City Peninsula. The assimilation of western and eastern diets also led to a lower demand for taro.

Groundwater pumping also had a tremendous effect on wetlands. The first well on Oahu was sunk in the Ewa Plain in 1879. Wells enabled irrigation which allowed the development of sugar in dry arid lands that were never cultivated by the early Hawaiians. Prior to the installation of wells, sugar was confined to the wetter uplands and to the heavy rainfall areas on Oahu. By 1910, there were 40,000 acres of sugar in production and 430 wells were drilled on Oahu. The accessibility of abundant water also fueled the rapid growth of agricultural, industrial, and urban developments. When the first well was dug, the fresh water lens was as high as 43 feet above sea level. The lens height dropped by roughly a third in thirty years due to the heavy pumping. Prior to the pumping, there were springs above Pearl Harbor from an elevation of 20-25 feet above sea level all the way to the ocean, as were a myriad of little streams. After the water table was significantly lowered, only a fraction of the streams remained and there is no doubt that wetlands were also adversely diminished.

Another significant influence on Hawaiian wetlands was the introduction of mangrove. The first mangroves in Hawaii were imported from Florida by the American Sugar Company in 1902. The sugar company used *Rhizophora mangle* on Molokai to prevent coastal erosion. A second shipment of mangroves arrived in 1922 from the Phillipine's Insular Bureau of Forestry. The seedlings included *Rhizpohora mucronata*, *Brugiera*

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sexangula, and *Sonneratia caseolaris* (Walsh, 1966). Since that time, mangroves have spread to all the Hawaiian islands. Large forests are present in the streams and undeveloped shorelines of Pearl Harbor.

Mangroves are prolific and spread through seedlings which are distributed with the tide. Aerial prop roots allow mangroves to take in oxygen and establish themselves in shallow water. Their tolerance for salt provides a competitive advantage over other plant species allowing monotypic forests to occur. Mangrove colonization also encourages sediment deposition which leads to further encroachment by mangroves. This cycle is evident at streams such as Halawa, Aiea, Kalauao, Waimalu, and Waiawa. Thus, buildup of sediments from natural erosion is exacerbated by mangroves.

The massive landclearing and dredging by World War II activities created a need for disposal areas. Wetlands provided convenient, under utilized areas which were filled and converted to upland uses. Filling occurred at Makalapa, Pearl City Peninsula, and Waipio Peninsula in both Navy and non Navy properties well before the implementation of the Clean Water Act of 1972.

Manmade wetlands, however, were also created and include the sugar process water settling ponds at Waipio, water features on golf courses, mitigation wetlands, and wildlife refuges. Channelization of streams and ditches have also caused wetlands to disappear and be created in other areas.

Wetlands are complex features that are constantly in flux and this report is a snapshot in 1999. The remainder of this chapter describes some of the characteristics of individual wetlands of Pearl Harbor.

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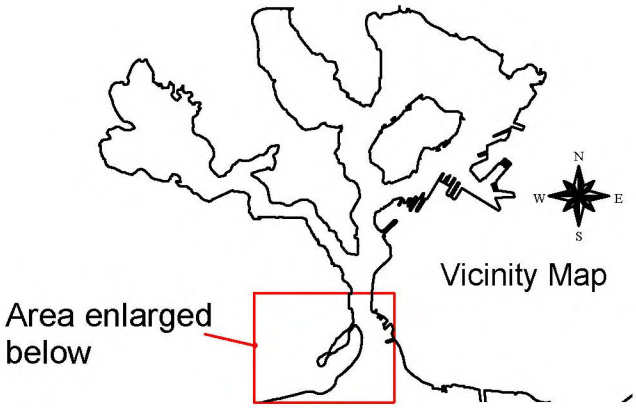

Photo from the 106th Street bridge at Iroquois Point Lagoon looking west. Mangrove colonize edges of lagoon.

U.S. Army Corps of Engineers
Honolulu District

Wetlands of Pearl Harbor

Figure 3 - Puuloa Rifle Range and Iroquois Housing Area

3.1 Segment 1 - Puuloa Rifle Range to Iroquois Point Naval Housing Area

Sandwiched between Ewa Beach and the west side of the entrance to Pearl Harbor is an area commonly referred to as Iroquois Point due to the presence of the Iroquois Point Naval housing area (See Figure 3). Iroquois Point is actually located 2,000 feet to the north of the Iroquois Point entrance channel on the shoreline of the Naval Magazine Lualualei West Loch Branch. The Puuloa Rifle Range is situated to the west of the housing area and is adjacent to Ewa Beach Park.

Figure 4 - Aerial photograph dated September 1950 by R.M. Towill Corp.

Figure 5 - Aerial photograph dated June 13, 1962 by R.M. Towill Corporation

The 1840 U.S. Exploring Expedition map (Fitzpatrick, 1986) shows the presence of a salt works inland of Keahi Point. The 1913 maps by the Corps of Engineers shows a set of roads in the vicinity of the salt works shown in the 1840 map.

One of the most prominent features of the Iroquois Point Naval Housing area is the manmade Iroquois Point Lagoon which was created by excavation of dry land. Figure 4 is an aerial photograph taken by R.M. Towill Corporation in September, 1950 prior to the development of the housing units which currently occupy the property. Figure 5 is an aerial photograph taken by R.M. Towill Corporation on June 13, 1962 showing the excavated lagoon and construction of housing units.

The edges of the smaller, inland lagoon are overgrown with stands of American mangrove (*Rhizophora mangle*) situated on a coralline bench. Within the mangrove, a sample point was taken only to find that the shovel could get to a depth of 7 - 9 inches in saturated, medium grained sand before hitting the coral reef. Scattered within the mangrove was a tidal debris line of beer cans, bottles, rubber slippers and plastic containers. *Milo* (*Thespesia populnea*) is the predominant species along the interior fence line with *'opiuma* (*Pithecellobium dulce*), *hau*

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(*Hibiscus tiliaceus*) and *kiawe* (*Prosopis pallida*) scattered throughout.

A boulder revetment lines the edges of the larger, northern lagoon. Within the revetment, mangroves can be seen growing in some areas. A sample point was taken and conditions similar to the smaller lagoon were found. The coral reef was encountered at a depth of 6 inches. At this sample point, the soil was composed of coarse grained sand. Vegetation consisted primarily of mangrove. A chain link fence confines the mangrove, *milo*, '*opiuma* and *kiawe* trees to the edges of the lagoon. Interspersed within the mangrove stands were small patches of pickleweed (*Batis maritima*) and Indian fleabane (*Pluchea indica*).

In the forty years since construction of the lagoon, sediment from erosion and runoff has accreted along the shoreline. Organic matter such as leaves also contribute to the sediment load. Based on sample points and field observations, the shoreline areas at the lagoon are considered wetlands as shown in Figure 6 below.

Figure 6 - Coastal wetlands at Iroquois Point Lagoon.

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3.2 Segment 2 - Naval Magazine Lualualei, West Loch Branch

The shoreline at this installation is an old exposed reef. Although the reef appears solid, long term exposure to waves has resulted in severe erosion and undermining, particularly near the mouth of the entrance channel to the lagoon (See Figure 7). Common wetland plants such as pickleweed, *hau* and *akulikuli* or sea purslane (*Sesuvium portulacastrum),* are abundant in the shoreline areas. However, the reef material and topography contribute to the lack of wetland hydrology and soil indicators on most of this shoreline. For most of this shoreline, wetlands were found in discrete isolated pockets. The shoreline is either too rocky or too exposed preventing large colonies of mangrove from becoming established.

Figure 7 - Erosion at entrance channel of Iroquois Point Lagoon.

There are 2 former fishponds/fishtraps and one impoundment at the West Loch Branch of Naval Magazine Lualualei (NAVMAGLLL) which were colonized by mangroves. In general, the ponds were former embayments which were enclosed by manmade outer walls. Some of the walls appear to have been modified but have long been abandoned and are overgrown by American mangrove. The fishponds are wetlands based on the criteria of the 1987 Corps of Engineers Wetland Delineation Manual. These wetlands are described from south to north in the following paragraphs.

The seaward most fishpond is called Loko Okiokiolepe (Figure 8) and is located just to the east of the training area called Cdr Heinz Ordnance Training Facility. The fishpond can be accessed by going around the fence at the training facility or by going through the access road on the west side of the pond. The back portions of the pond are tidally influenced

Figure 8 - Loko Okiokiolepe. View towards Pearl Harbor entrance channel. Wetland #2100102206

According to the State Historic Preservation Division's fishpond map, the second pond is called Loko Pamoku. This is a smaller pond than Loko Okiokiolepe. It is accessed by going down G Avenue headed towards Waipahu and taking a right turn onto a dirt road

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just past the secured bunkers. This fishpond is also colonized by mangroves with patches of pickleweed behind it (Figure 9). The soil in this area is a dark odoriferous muck.

Figure 9 - Pickleweed patch behind mangroves at Loko Pamoku fishpond. Wetland #2100102207

The third impoundment is shown on Figure 10 and is not identified in the Bishop Museum map (Sterling and Summers, 1978) nor on the State Historic Preservation Division's fishpond map. This pond is located off of the former officers' quarters located at the end of B Avenue and may have been constructed by the military. Old maps refer to the headland at this location as Nichols Point. An interior wall separates the pond into two cells. The homes and structures there have all been removed but the paved road and some of the sidewalks are still intact. Because this pond is not mapped, and most of the structural features are concrete, it is not known whether this was a historic fishpond whose walls were covered with concrete or whether it was built entirely by the military from scratch. A search of the permit logs did not provide any clues as to who built/improved the pond walls or when the improvements took place.

Figure 10 - Interior of unnamed impoundment looking towards harbor. Wetland 2100102213

A sample point was taken at the back of the impoundment. This area is tidal as evidenced by the debris line. Vegetation was 100% American mangrove in this area as in most of the edges of this pond. Soils were black and anaerobic. Tilapia was abundant in both cells of this pond.

Previous wetland surveys by Elliott and Hall, Ahuimanu Productions, and the National Wetland Inventory do not indicate any wetlands in the interior sections of NAVMAGLLL West Loch Branch. Due to the high security of this installation, we drove through the roads in these interior sections to determine if wetlands were present. An extensive walk through was not conducted as the probability of wetlands is low due to the topography, precipitation patterns, and lack of wetland vegetation.

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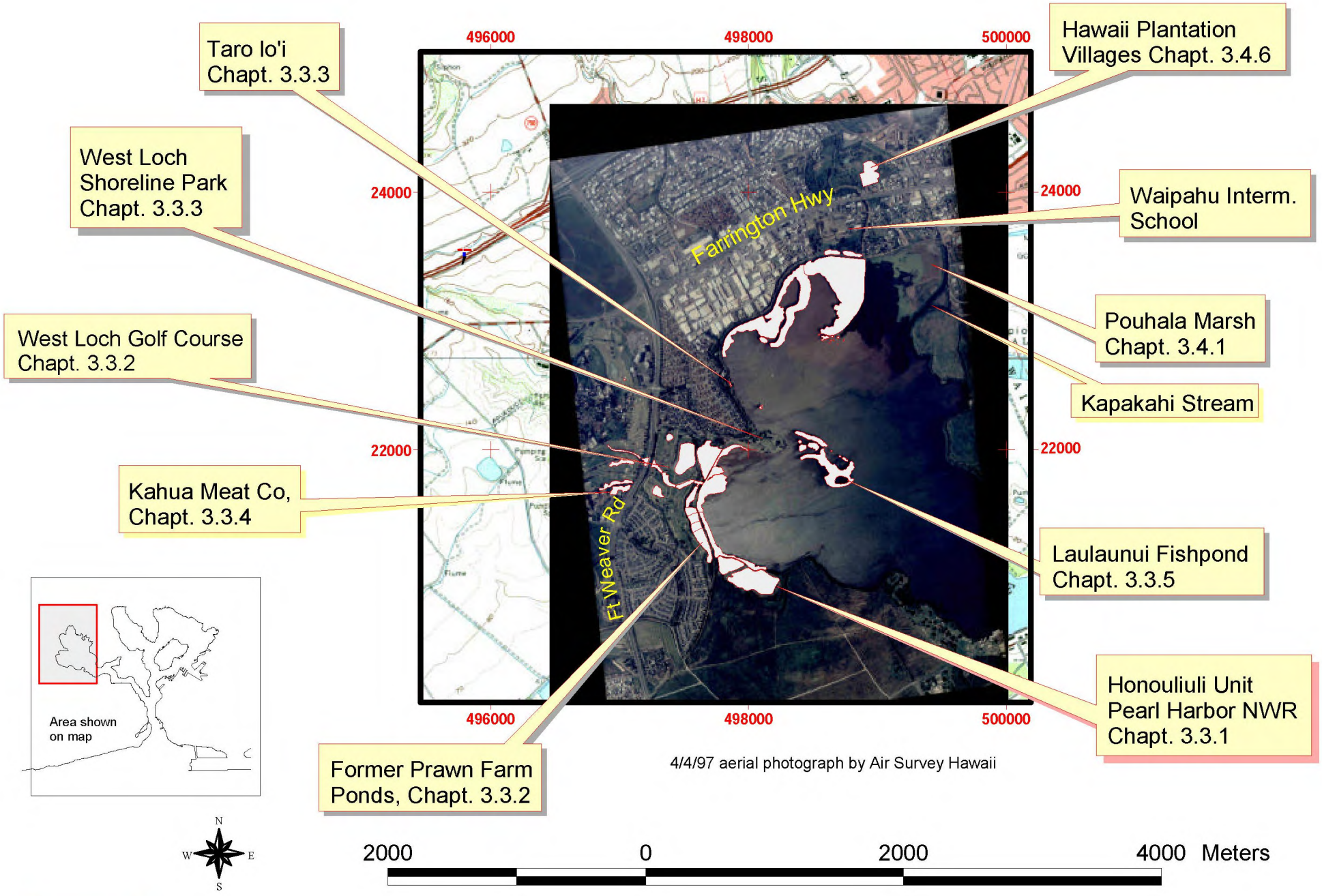

4/4/97 aerial photograph by Air Survey Hawaii

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Honolulu District

Figure 11 - West Loch Shoreline

Wetlands of Pearl Harbor

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3.3 Segment 3 - West Loch Shore (Waiawa Unit Pearl Harbor NWR to Waipahu Interm School Canal)

Figure 11 shows some of the features in this segment. Wetlands can be found at the Honouliuli Unit of the Pearl Harbor National Wildlife Refuge, abandoned prawn ponds, West Loch Shoreline Park, West Loch Golf Course, and along the Waipahu shoreline.

3.3.1 Honouliuli Unit, Pearl Harbor National Wildlife Refuge

The U.S. Fish and Wildlife Service (USFWS) maintains and operates the Pearl Harbor National Wildlife Refuge (PHNWR). The PHNWR is split into the Waiawa Unit (located at Pearl City Peninsula; see description chapter 3.6.7) and the Honouliuli unit located near the abandoned prawn farm.

Aside from the agriculturally farmed wetlands, the PHNWR are the only wetlands that are actively managed for wildlife. Other mitigation sites occur but they are not actively managed. The differences between managed and unmanaged wetlands are significant. At most sites, vegetation control is the most important and most costly aspect of wetlands management. For unmanaged areas, vegetation will choke the wetlands unless the water is deep enough to prevent vegetation from rooting. However, deep water is not favored by wading waterbirds such as the Hawaiian Stilt.

The ability to adjust and control water levels is critical to maintaining shallow water habitat necessary for waterbird production. Without shallow water or mudflats, the waterbirds have no foraging area and they become susceptible to predation. Both the Honouliuli and Waiawa units utilize pump and outlet control structures to regulate water levels. The two cell pond systems at both units clearly demonstrate Hawaiian Coot and Hawaiian Stilt preferences for shallow (0-9 inches) water habitat.

On 13 August, 1999, we were escorted to the Honouliuli unit by Mr. Michael Silbernagle of the USFWS. The refuge is split into a west pond and east pond. The interior of the west pond contains hydric vegetation such as cattails (*Typha latifolia*), knotgrass (*Paspalum distichum)*, spike rush (*Eleocharis sp.)*, *makai* (*Bolboschoenus maritimus*). Indian fleabane covers some of the islands and is also found on the edges of the ponds. Mr. Silbernagle indicated that the cattails are favored for nesting by the coot and moorhen.

To maximize the efficiency of the limited staffing resources, the USFWS focuses their management on the east pond. The east pond contained cattails, knotgrass, *makai*, water hyssop (*Bacopa monnieri*) and Mexican sprangletop *(Leptochloa uninervia)*. While the west pond had few birds, Mr. Silbernagle counted 180 coots at the east pond earlier in the morning with smaller numbers of stilt, moorhen, and shorebirds. A channel runs between the two ponds and contained American mangrove, knotgrass, and Indian fleabane. This tidal area is also a wetland.

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Outside of the Honouliuli Unit, there is a strip of mangroves at the shoreline with a pickleweed flat on the landward area behind it. Indian fleabane, *kiawe*, and *milo* are also found in this wetland. Chevron is replacing some of the pipeline in the right-of-way and excavated a 3-4 foot deep trench. The ground was dry and the soil did not appear hydric.

Figure 12 - Photograph of the east pond of the Honoululi unit, PHNWR. Wetland #2100103165

There is a large sump at the east edge of the West Loch housing subdivision. This sump is fenced (although it appears that large sections of fence had been stolen) and one can hear large flocks of birds roosting at night. Mr. Silbernagle indicated that when the subdivision was being built, a large quantity of silt had entered the refuge. To mitigate for the silt, the developer built this sump area for drainage. There is no way for water to get out except by percolating into the ground. The sump contained no water and was predominantly *kiawe*. This area is not a wetland.

3.3.2 West Loch Golf Course

The West Loch Golf Course is a part of the City and County of Honolulu municipal golf course system. A small stream traverses the golf course (Figure 13). The stream is choked with California grass (*Brachiaria mutica*), water hyacinth (*Eichhornia crassipes*), and cattails. During heavy rains, much sediments are trapped in the waterway and the adjoining fairways are occasionally flooded. Ponds are also interspersed throughout the golf course. The driving range is a pond which golfers hit floating balls into its waters.

Figure 13 – Photograph from Fort Weaver Road of stream at West Loch golf course. Wetland #2100103174

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Adjacent to the driving range is Ka'auku'u fishpond. Culverts allow tidal interchange with West Loch. The edges of this pond are colonized by mangrove and Indian fleabane. Park users frequently fish in this pond.

Figure 14 - Mudflat at former prawn farm. Wetland #2100103163

Farther to the south are four ponds formerly used for salt production and later for prawn farming (Figure 14). These ponds are heavily vegetated by American mangrove, Indian fleabane, sourbush (*Pluchea odorata*), Fosberg's fleabane (*Pluchea* x *fosbergii*), cattails, and pickleweed. There is still open water and the heavy vegetation helps to keep the area secluded. Hawaiian stilt were seen at these ponds on several occasions.

3.3.3 West Loch Shoreline Park (reference permit no. NW88-040)

American mangroves and pickleweed are halophytes (plants which tolerate high salinity) that colonize the mudflat and shoreline. The mangrove are viviparous, that is they germinate while still on the plant. The propagule, which drops from the tree and floats with the tide, consists of a seedling with an extended hypocotyl and a plumule. Mangrove distribution is thereby controlled by the influence of the tide.

Once they become established, mangroves can grow into huge forests and dominate an area. The shoreline of the park was cleared of adult mangroves in the early 1990's with the development of the park. A lot of it has grown back despite efforts to control the mangroves. Like a double edged sword, the mangroves can prevent shoreline access and spoil the view plane. However, mangroves can help to reduce shoreline erosion and allow solids to settle in the water column rather than being pushed straight into the sea.

One of the problems with the wetlands in this area is that someone feeds the cats near the vicinity of the driving range. At least ten bowls of food and water were seen on several occasions and at least 6 different cats were seen in the area. Cats and mongoose are known to prey on waterbirds and other animals that use wetlands, reducing biodiversity in the area.

Figure 15 - Taro and water lilies at West Loch Shoreline Park. Wetland #2100103185

On the north side of the park, there are several homes with a banana patch and a pond. Taro is raised in this

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pond which also contains water lilies (Figure 15).

3.3.4 Kahua Meat Company (Reference permit no. NP90-028)

Figure 16 - Kahua Meat Company wetland, Honouliuli. West Loch Golf Course in background. Wetland #2100103167

Located at the intersection of Old Fort Weaver and Fort Weaver Roads in Ewa, Kahua Meat Company is a slaughterhouse that processes livestock. Some of their sewage is treated in this pond adjacent to West Loch Golf Course's 10th tee and Kahua Nursery. The interior of the pond is dominated by California grass. Cattail and duckweed (*Lemna sp.*) are also found here. Indian fleabane, *milo*, and castor bean (*Ricinus communis*) are found on the edges of the wetland.

3.3.5 Coastal and Islet Mangrove Forests

Just offshore of the West Loch Shoreline Park is a number of islets and mangrove clusters which include Laulaunui fishpond and island. In this report, Laulaunui Island refers to the main island which is the largest and tallest rising 40-50 feet above sea level. To the southeast is a smaller island which appear on aerial photographs to be connected to the main island. However, there is an opening which is covered by American mangrove. A trail has been cut in the coral forming a path between the two islands. The water was 6-12 inches deep between the two islands at high tide. The islands were formed on an old coral reef which contained a lot of old oyster beds at a time when the water level was much higher. *Kiawe* dominates the upland areas with very little grass on the islands. American mangrove covers the shoreline areas and the islets surrounding the main island.

The fishpond is on the seaward end of the island. Mangroves obscure the walls and openings, and the interior of the pond is inaccessible by boat. The footprints of several buildings are on this island. Photographs of and on this island can be found in Appendix B in the section entitled *Boat Survey of Pearl Harbor*.

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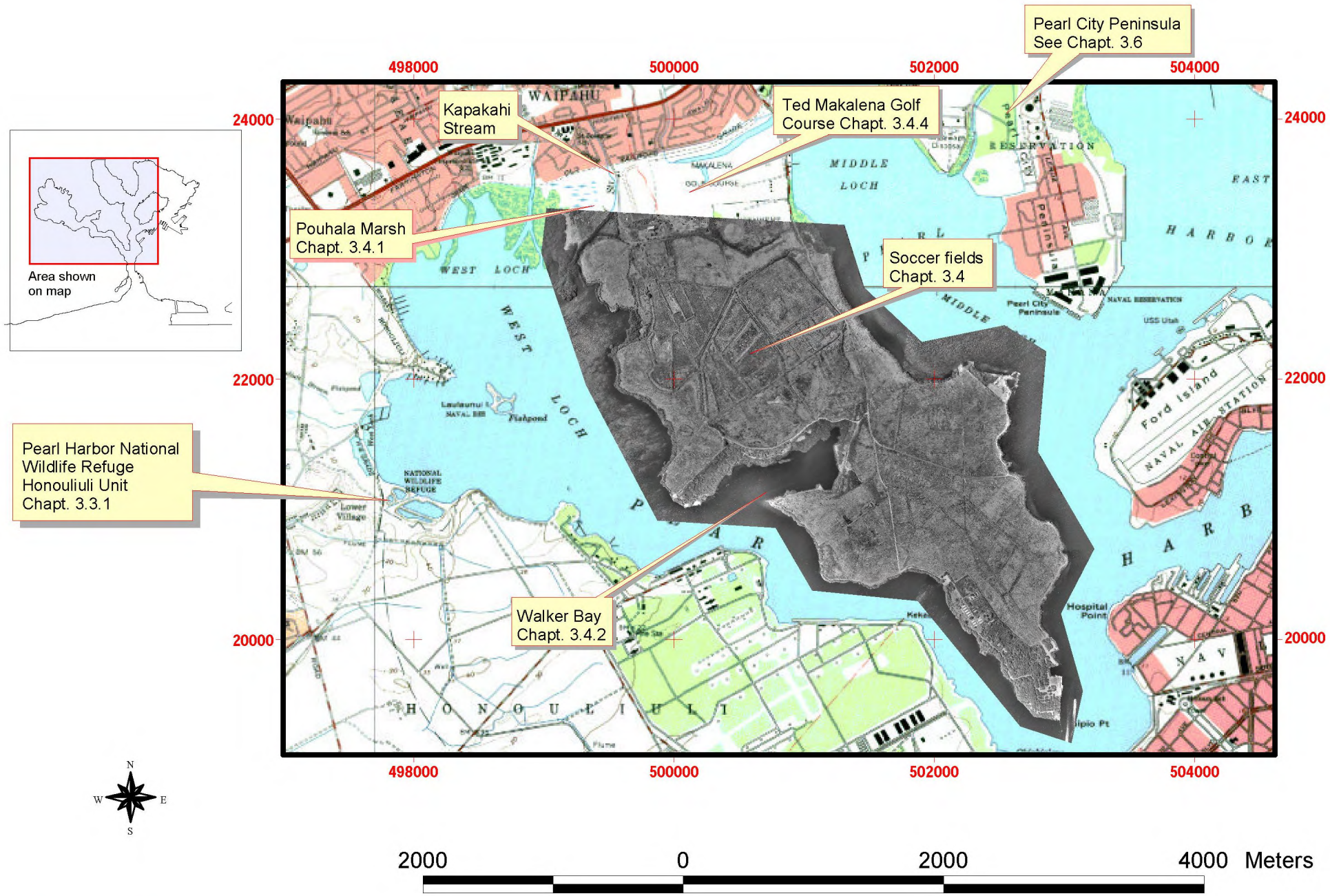

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Figure 17 - Waipio Peninsula

Wetlands of Pearl Harbor

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3.4 Segment 4 - Waipahu Interm School Canal to Waipahu H.S. Channel (Waipio Peninsula)

Loko Hanaloa and Loko Eo were two of the largest fishponds in Pearl Harbor. These and other smaller fishponds were situated on Waipio Peninsula but most have been filled. In the late 1890's, Oahu Sugar Company leased a large portion of Waipio Peninsula. Sugar cane was cultivated over most of the lands and drainage and irrigation systems were installed. Sugar cane has since been phased out and there are still Navy facilities in use on the peninsula. Mangroves have proliferated into large forests at sheltered areas of Waipio Peninsula.

The existing features of Waipio Peninsula are shown on Figure 17. A large portion of the peninsula closest to the Ted Makalena Golf Course is currently being developed into the City and County of Honolulu's Waipio Peninsula Soccer Park. The Final Environmental Impact Statement (FEIS) has been scanned in Adobe Acrobat PDF format and is included in the CD. The FEIS contains maps, using aerial photographs as a base. A majority of the park will be built on lands leased from the Navy.

3.4.1 Pouhala Marsh

Pouhala Marsh is located on the northwest corner of Waipio Peninsula and is bounded by Kapakahi Stream, a landfill area, mangrove forest and the bicycle path/access road. Waikele Stream flows on the western side of the marsh behind the mangrove forest. Kapakahi Stream flows on the eastern side of the marsh, along Waipahu Depot Road. Water ponds in a large mudflat area on the east side of the property. Hawaiian Stilt were observed on every visit to this mudflat. Similar to other areas of Pearl Harbor, American mangrove and pickleweed colonize the shallow areas, shoreline, and mudflat areas.

Ducks Unlimited, Inc. (1998), prepared an Environmental Enhancement Plan for Pouhala Marsh on behalf of the State Division of Forestry and Wildlife, U.S. Fish and Wildlife Service and the City and County of Honolulu. The proposed plan would enhance wildlife habitat in the marsh by removing trash and 66,000 cubic yards of fill, fencing, vegetation clearing, and creating a hydrologic connection to Kapakahi Stream. The plan has been scanned into Adobe Acrobat PDF format and is included in the references folder of the CD (Pouhala.pdf).

3.4.2 Coastal Mangrove Forests

Mangrove forests occur along the shorelines primarily along embayments and low energy shorelines of Waipio Peninsula. Walker Bay is a large indentation on the west side of the peninsula which contains a lot of mangroves on its edges. The shoreward edges of the forests contain *milo* and patches of pickleweed indicating the probable shoreline prior to mangrove colonization.

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3.4.3 Oahu Sugar Settling Ponds

Oahu Sugar Company was formed in 1897 and leased a large portion of the Waipio Peninsula for sugar cultivation. For many years, the company used a series of ponds on lands leased from the Navy to remove silt from the Waipahu sugar mill processing water discharge. The wetlands of Waipio Peninsula have been significantly changed with the ending of sugar operations in 1992. These ponds provided large wetland areas which were noted by Ahuimanu Productions (1977) as providing the best waterbird habitat on Waipio Peninsula. Figure 18 shows areas which were informally considered wetlands by the Corps prior to the end of sugar production. The ponds and the interior of the peninsula are now dry and no wetlands were found in the area. The soccer fields are being built over the primary ponds. We visited the former pond locations and found some with hydric vegetation such as Indian fleabane, Fosberg's fleabane, sourbush and California grass. However, the lack of water being pumped into these areas have resulted in the removal of the hydrologic component to call these areas wetlands. Some of the soils and vegetation appeared to be drying out as the areas change to uplands. Guinea grass (*Panicum maximum*), castor bean, *koa haole* (*Leucaena, leucocephala*), spiny amaranthus (*Amaranthus spinosus*), buffel grass (*Cenchrus ciliaris*), ivy gourd *(Coccinia grandis*) and swollen finger grass (*Chloris barbata*) are also in these former pond areas.

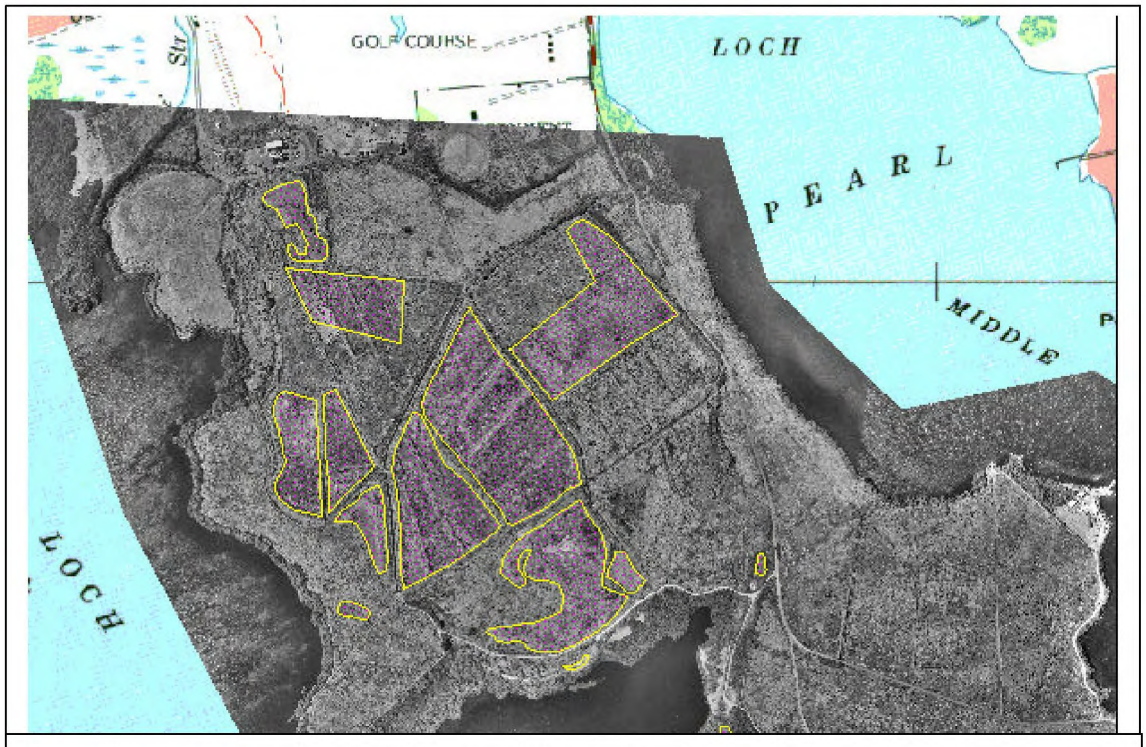

Figure 18 - Areas mapped as potential wetlands by previous Corps mapping project.

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3.4.4 Ted Makalena Golf Course

Golfers who use this municipal course are familiar with the frequently muddy conditions over some of the fairways. The high salinity restricts grass on these affected fairways. The Wailani drainage channel passes through the course and both banks are colonized by mangroves. The sides of the unlined channel meet the wetland criteria.

3.4.5 Wetland below Waipahu Intermediate School (Ref. permit no. 980000116)

This depressional wetland is surrounded by Pupuole Mini Park, Waipahu Intermediate School, Waikele Stream, and the railroad right-of-way. Waipahu Intermediate School is on a bluff overlooking the park and wetland. The park is at a higher contour than the wetland and elephant grass is the primary vegetation between the park and the wetland. The railroad right of way forms a barrier between a mangrove coastal wetland and the subject wetland which is dominated by bulrush (*Scirpus validus*). Vegetation transitions from elephant grass (*Pennisetum purpureum*) to California grass before it reaches Pupuole Mini Park. On the eastern end, the wetland transitions into elephant grass before emptying into a waterway named on the site plan as Waipahu drainage canal. The vegetation near the right-of-way includes umbrella sedge (*Cyperus involucratus*), spiny amaranthus, Indian fleabane, sourbush, *koa haole* and castor bean.

3.4.6 Hawaii Plantation Village (Reference permit no. V90-048)

Hawaii Plantation Village is located in Waipahu below the old sugar mill. The buildings of the Hawaii Plantation Village are located on the higher elevations of this property towards the sugar mill. Fringes of the park are within the wetland and there are small ponds near the plantation homes. This wetland is in and adjacent to the village and Waikele Stream. However, there is a dam which prevents interchange of water between the stream and the wetland. According to one of the farmers in the area, there are springs which feed the area and the water is directed to the east towards Waipahu Depot Road where the drainage system takes the flow towards Pearl Harbor.

A large part of the wetland is currently leased for farming taro. This wetland covers approximately 7.5 acres. The Lau family uses most of the wetlands but smaller farmers lease portions of the wetland for growing taro and other crops. The spacing between taro plants provided good foraging conditions for waterbirds. During our visit on 1 October 1999, we saw 5 Hawaiian Stilt in the ponds. Apple snails are abundant and a major problem for taro farmers. Water hyssop was common in untended taro plots. *Honohono*, duckweed, Jobs tears and umbrella sedge were also observed. In addition to the taro, there was a wide variety of vegetables being cultivated in dry areas including the berms around the ponds.

This area is not on Navy property and a reconnaissance level wetland survey was conducted. The area was mapped as one wetland rather than a multitude of small wetlands.

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3.5 Segment 5 - Waipahu H.S. Channel to Pouhala Marsh (Middle Loch Shoreline)

Kolea Cove Wetland

Figure 19 - West side of Kolea Cove wetland. Moorhen observed at rear of pond in circled area. Wetland #2100105285

In July, 1984, DA permit number 1594-S was issued to Okada Trucking Company to construct three storm drain outlets and discharge approximately 15,000 cubic yards of fill into a wetland in conjunction with a housing project. To mitigate for the loss of wetlands, a wetland pond was created at this site. The housing project is on hold but the pond was constructed and is maintained by Kauhale Kai Limited Partnership. The wetland is slightly over an acre in size and is located mauka of the bicycle path beneath Waipahu High School.

A chain link fence helps to control waterbird predators. Vegetation includes cattails sourbush, Indian fleabane, ung choy (*Ipomoea aquatica*), and umbrella sedge. Naupaka (*Scaevola sericea*) has been also been planted at the edges above the wetland area. A Hawaiian Moorhen was seen during one of the visits to this pond. This was one of only three observations (during the field studies) of this endangered species outside of the refuges.

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3.6 Segment 6 - Pearl City Peninsula (Waiawa Unit, Pearl Harbor National Wildlife Refuge to Waimanu Stream)

The Pearl City Peninsula is bisected by Waiawa Stream and is used, among other things, for military operations, residential housing, fuel storage, a sewage pumping station, and a wildlife refuge. Most of the development and principal activity are found in the area east of Waiawa Stream. Large mangrove forests cover a major portion of the undeveloped shoreline areas. Landward of the peninsula, there is still a fair amount of agricultural activities in wetlands.

Paul H. Rosendal Inc. prepared an archaeological report of the area for the *Waiawa Floodplain Feasibility Study* (Helber, Hastert, and Fee, 1994) and included an 1897 map (Figure 20) of the peninsula. At the time of the 1897 map, most of the area was in rice and taro production and there were at least four fishponds (Loko Kuhia Loho, Loko Apala, Loko Pa'au'au, and Loko Weloko). Major changes in land use from agricultural to urban and industrial have significantly reduced the amount of wetlands in the Pearl City Peninsula. All of the rice fields and fishponds have been either filled or covered with mangroves and are no longer in use. A large portion of the area west of Waiawa Stream was used as a landfill for solid and hazardous waste disposal in the 1960's and 1970's.

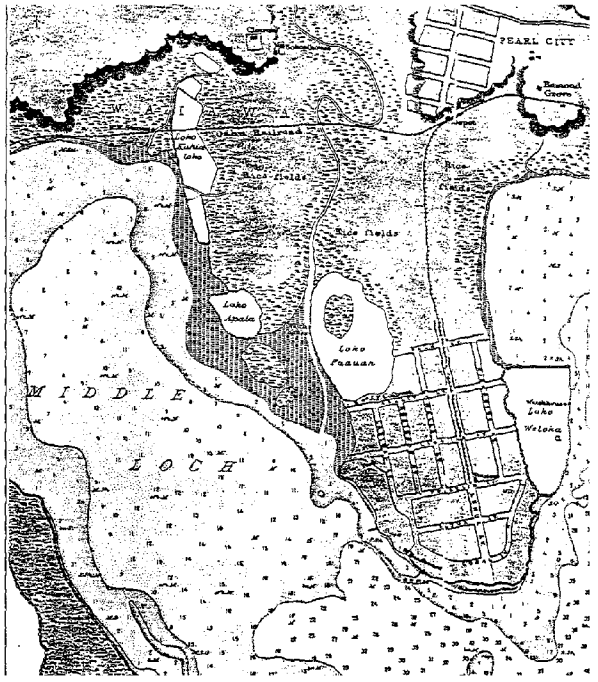

Figure 20 -1897 Historic Land Use Map by PHRI, Appendix from Waiawa Floodplain Feasibility Study (Helber, Hastert and Fee, 1994)

Figure 21 shows the Pearl City Peninsula (PCP) and location of sites described in this chapter. Large mangrove forests persist on the undeveloped shorelines, Waiawa Stream, and in one of the drainage ditches along the landfill. The Waiawa Unit of the Pearl Harbor National Wildlife Refuge is also one of the remaining major wetlands in the area and Pearl Harbor and provides mudflats and shallow water habitat for endangered waterbirds. Another wetland area is the pickleweed fields located behind the abandoned Pearl City sewage treatment plant (STP) west of Waiawa Stream. Another large wetland area is at the area north of the tank farm and bounded by the bicycle path, the sewage pump station, Lehua Avenue, and Waiawa Stream. Inland of the Peninsula, agricultural activities still occur in the wetlands along the Waiawa floodplain.

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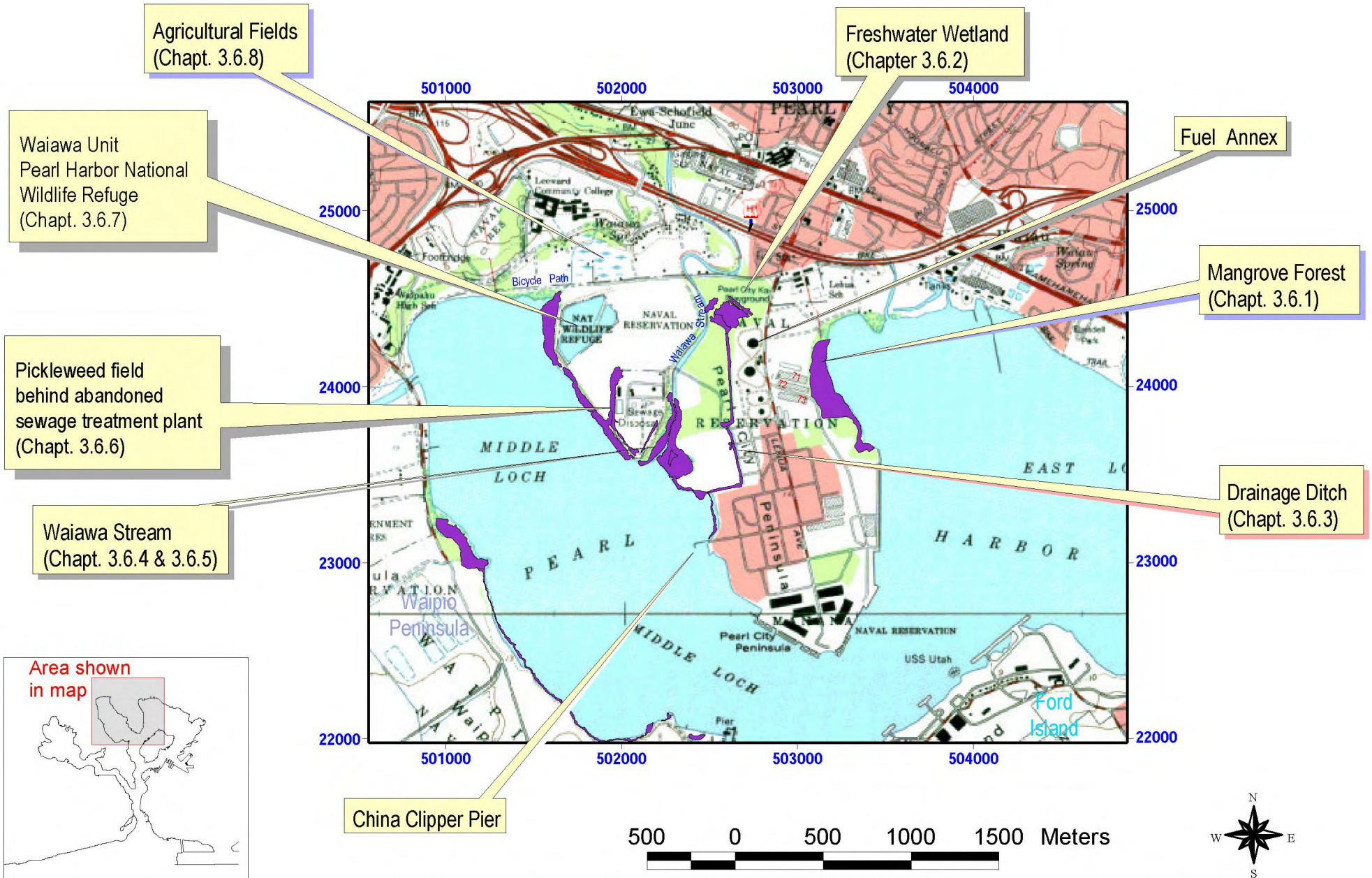

Figure 21 - Pearl City Peninsula Site Map

Wetlands of Pearl Harbor

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3.6.1 Mangrove forest on east shoreline

Figure 22 - Mangrove forest on east shoreline of Pearl Citv Peninsula. Wetland #2100106102

On the east shoreline of the Peninsula, there is a large mangrove forest beginning from the Waiau power plant and extending to the first pier in the middle of the peninsula (Building 992). The Navy property on this portion of the peninsula has been built up by at least 5 feet of fill. There is a large nonwetland area consisting primarily of construction debris and fill on the southern end of the forest. The upland areas slope down to a mudflat that extends to the shoreline. *Koa haole*, buffel grass and *milo* are abundant from the top of the fill down to the base of the slope. Other upland species in the area include *Achyranthes aspera, Helitropium procumbens var. depressum*, and comb hyptis (*Hyptis pectinata*). As shown in Figure 22, the forest of American mangrove rises 50-70 feet high and extends from the base of the slope to the edge of the shoreline. Remnant patches of sea purslane can be found landward of the forest. These are likely to be the areas of the former backshore areas prior to colonization by mangroves.

Fig 23 - Soils towards seaward edge within mangrove forest.

Behind the warehouses (Buildings 71, 72, and 73), this wetland contained ponded water 4-10 inches deep and schools of mosquitofish *(Gambusia affinis*) were observed. Blackened leaves covered the bottom. A scorpion was observed in the ponded water area outside Building 72 (middle warehouse).

The soils are mapped as Pearl Harbor Silty Clay and the general description matches what was found in the field. The soil is dense and firm. We did not sink as we walked through the forest. The first several inches of the soil is mostly roots and peat. Beneath this horizon, the soils were gleyed clay (Figure 23). See data sheets for more information.

The area is tidally influenced as seen by the recent water line on the trees that were several inches higher than the water level at the time of the visit. A debris line inland of the shoreline is further evidence of tidal influence. All three parameters were met and the mangrove forest is considered a wetland under the criteria of the Corps of Engineers 1987 Wetland Delineation Manual.

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3.6.2 Wetland between Fuel Annex, Waiawa Stream, bike path and Lehua Avenue

This wetland was the subject of a 1994 study for a sediment removal facility and a wetland delineation was performed by the Corps. The delineation was included in the final report whose technical appendices also included a botanical study, soils investigation, and archaeological report. The study and its appendices have been scanned into Adobe Acrobat format (PCPFld.pdf) and are included in the references section of the CD that accompanies the present wetland mapping report.

Two berms criss-cross the site as shown in figure 24. The first berm has a City and County utility easement running from the City and County pump station to the abandoned sewage treatment plant on the west side of Waiawa Stream. This easement includes a pipeline crossing over Waiawa Stream and overhead lines. The second berm has an 8-inch underground fuel line and runs from the fuel annex to the northwest corner of the property. Both berms are choked with heavy vegetation including elephant grass, monkeypod, and Java plum *(Syzygium cumini)*. Both berms also have low points which are breached during floods. The berms divides the area into four quadrants with three of these quadrants containing wetlands. We walked the entire perimeter of each of the wetlands.

The north quadrant is the smallest and closest to the sewage pump station. This area is dominated by elephant grass and Guinea grass and is the smallest quadrant. Large monkeypod (*Samanea saman*) trees cover the area near the bicycle path with an opening for the sewer line berm. *Macaranga tanarius,* castor bean, and Java plum are also common. This area does not contain wetlands.

In the previous delineation by the Corps, the east quadrant contained more wetlands than in the present study. We took two sample points in the highest lobe of the California grass wetland. The soil was very well drained and was not saturated, even at 18 inches beneath the surface. A couple of hundred feet towards the ocean, the soil and hydrology are much clearer with standing water in the summer months and obligate wetland plants. The soil was darker and exhibited more distinct mottling patterns. Water crosses the berm and feeds into the wetlands of the south quadrant. Job's tears (*Coix lachryma-jobi*), umbrella sedge, California grass, primrose willow (*Ludwigia octovalvis*) and *honohono* (*Commelina diffusa*) are found in these areas.

The drainage ditch controls the water level in the south quadrant. There are two wetland communities in the south quadrant: a California grass meadow and a mixed forest wetland. Just upstream of the ditch, there are several inches of standing water in a California grass dominated wetland. Job's tears, umbrella sedge and primrose willow are also found here as are castor bean, Java plum, and monkey pod trees near the edges. By far, the dominant wetland species are the California grass and umbrella sedge which form nearly monotypic stands. *Maile pilau* (*Paederia scandens*) weaves through this wetland, particularly on the edges.

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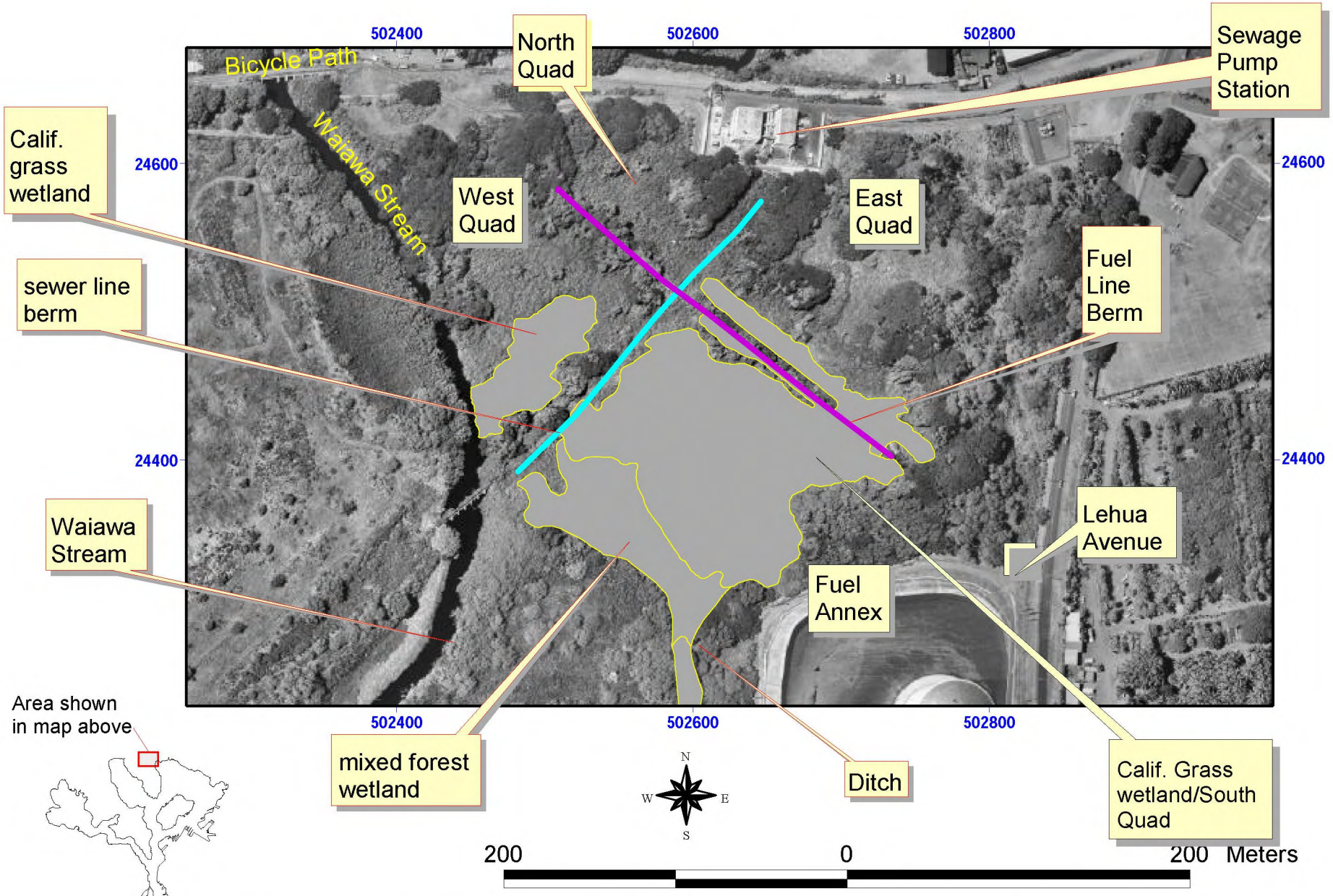

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Honolulu District

Figure 24 - Pearl City Peninsula Freshwater Wetland

Wetlands of Pearl Harbor

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West of the ditch, the landfill ends at about the beginning of the ditch and proceeds towards Waiawa Stream. There is a grove of *hau* (*Hibiscus tiliaceus*) between the boundary the wetland and fill. This area is best described as a mixed forest interspersed with wetlands. Coconut trees (*Cocos nucifera*), Christmas berry (*Schinus terebinthifolius*), dates, and Java plum are found in this area. Surface water runs through the forest area and duckweed and Jobs tears can be found in some of these areas. The entire area was mapped as a wetland as shown on figure 24 which is consistent with the previous delineation.

Six data points were taken and supplemented with the data sheets from the 1993 wetland survey. See appendices from the *Waiawa Floodplain Feasibility Study* (Helber Hastert and Fee, 1994) for previous wetland data sheets, soil survey, botanical survey and archaeological survey. The wetland area has decreased since the last survey due to heavy vegetation growth. All of the trails, including the berms, are choked with vegetation and we spent many days cutting trails.

The fuel annex is located east of the drainage ditch. The area is built atop former rice fields and fill extends to the tree line to the north forming the boundary for the wetland. This area proceeds towards Lehua Avenue before swinging around towards the sewage treatment plant. Elephant grass and monkeypod are common. *Kiawe* and *koa haole* are common on the filled area. The fuel annex does not contain wetlands.

The west quadrant also contained a California grass and umbrella sedge wetland. The water table is high and the soil had low chroma. Elephant grass is encroaching into the area and is decreasing the jurisdictional area.

3.6.3 Drainage ditch from wetland #2100106098 past tank farm, to housing area to Middle Loch

There is a drainage ditch west of the fence line which extends from the west side of the tank farm south to the housing area which then proceeds west to Middle Loch. This ditch is in the approximate vicinity of the south and west boundaries of the former Loko Paauau fishpond. American mangrove dominates the banks and center for the entire length of the 40-50 foot wide ditch.

Other plants along the banks in the lower reaches include *hau*, *milo*, Indian fleabane, and *koa haole*. In upper reaches of the ditch, Indian fleabane, sourbush, California grass, umbrella sedge, and duckweed (*Lemna sp.*) are more common.

The ditch contains standing water from the beginning to the end. In the lower reaches near the outlet we observed tilapia and barracuda in depths of one to two feet. In the higher reaches, mosquito fish are abundant and depths are generally less than one foot.. Tilapia were seen as far upstream as the vehicular bridge on Waipuna Avenue.

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The soils were not checked because standing water was present on multiple visits to the Pearl City Peninsula. Water blackened leaves and the odor of decomposing organic matter attests to the anaerobic conditions that the soils in this ditch are subjected to. The area meets the Corps 1987 Wetland Delineation Manual definition of a wetland. Wetland numbers 2100106093 through 2100106097, and 2100106287are all a part of this ditch system.

The interior of the peninsula between the drainage ditch, housing area, and Waiawa Stream, is all landfill and do not contain any wetlands. The vegetation is best characterized as dry scrub. Guinea grass, koa haole, kiawe, and Indian fleabane are common species.

3.6.4 Mangrove and Milo Forests along Waiawa Stream

The undeveloped portions of the western shoreline of Pearl City Peninsula is dominated by mangrove. The mangrove forest extends into Waiawa Stream on both sides of its banks. Loko Paauau was formerly located on the eastern side of the stream prior to being filled.

The stream bottom is tidally inundated up to the bottom of the banks which results in daily saturation of the soil. Soils were sampled on both sides of the stream. In general, the soils were dark and mucky with a lot of organic material.

The accreted areas beyond the toe of the banks are almost monotypic stands of American mangrove with milo, Indian fleabane and Christmas berry encroaching on the banks. Looking glass tree (*Heritiera littoralis*) was also seen within the American mangrove forest on the east side of Waiawa Stream. The upland vegetation is primarily *koa haole*, *kiawe*, Guinea grass, buffel grass and Indian fleabane. The mangrove forest is considered a wetland between the toes of the two banks.

Upstream and on the west side of Waiawa Stream, the banks are steep with drops ranging from three to six feet to the water surface. Between the bicycle path and the Waipuna Avenue bridge (currently under construction), dense thickets of *hau* line the stream bank with smaller patches of California grass, pickleweed, and elephant grass interspersed between the *hau*. Although the *hau*, California grass and pickleweed are hydric vegetation, the soils were dry and crumbly with no wetland hydrology indicators. Thus these areas are not considered wetlands.

Downstream of the Waipuna Avenue bridge, *hau* is found along the bank which gradually slopes into the stream. Here the vegetation transitions into mangrove. A berm separates the mangrove forest from a small field of pickleweed. In this location, a sample point was taken and it was determined that this is a tidally influenced wetland.

AR00044240

Mullet, tilapia, and mosquito fish were observed. The only waterbirds seen near the stream were several *Aukuu* or black crowned night heron (*Nycticorax nycticorax hoactli*).

3.6.5 Pickleweed field behind mangroves east of Waiawa Stream

The shoreline east of Waiawa Stream up to the China Clipper pier is also colonized by a strip of American mangrove. Behind the mangrove, there is a flat stretch of land that extends to the base of the fill. This flat area is covered by large patches of pickleweed and is influenced by the tide (Figure 25). The soils come from the fill area and is mostly red soil with a lot of gray colored rocks. The 1897 land use map (Figure 10, from Helber, Hastert and Fee, 1994) seems to indicate that either a mud flat or Loko Paauau fishpond was previously located in the area.

Figure 25 - photo taken at high tide, 25 Aug 1999. Wetland #2100106090

The debris line contained flotsam such as slippers, balls, seed pods, and paper cups typically found at other tidal mangrove forests in Pearl Harbor. A test pit was dug during low tide on 14 Jul 1999 and the red and brown soils contained rocks and gravel. The water table was 13 inches below ground level. The site was visited during high tide on 25 Aug 1999 and the area was inundated. Thus it appears that the soils from the edge of the fill are mixing with the soils in the inundation area and an atypical situation is occurring. Based on the inundation and the prevalence of hydric vegetation, the area is functioning as a wetland and meets the definition of a wetland.

This is an atypical situation in that the soil indicators are masked by the fill material placed on the adjacent shoreline. However, it is clearly evident that the soil is influenced by the tide and saturated daily. The plants are obligates and this area is considered a wetland.

3.6.6 Pickleweed field behind Pearl City Sewage Treatment Plant (STP)

The Pearl City STP was abandoned presumably after the construction of the Honouliuli STP. Located west of Waiawa Stream, the area is overgrown by vegetation and sees relatively few human visitors. Some of the old tanks and basins collect water and were in use by stilts.

The STP was built upon fill which slopes towards the sea. At the edge of the STP, the topography drops off and the water collects in a pickleweed field (Figure 26). During several site visits in this area, large portions of the field contained standing water with a

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few pockets containing up to two feet of water. A road placed upon fill extending to the shoreline forms the eastern barrier for the wetland. The toe of the landfill marks the western boundary of this wetland. Mangroves extend from the end of the landfill to the ocean and continues along the shoreline.

Figure 26 - Area to far left is landfill. This slopes down to the road. After the level road area, a slope takes you down to the low lying pickleweed field. Wetland #2100106084

Some of the areas appeared to have salt deposits where only pickleweed and Australian saltbush (*Atriplex semibaccata*) appeared healthy. Indian fleabane and *kiawe* species appeared to be stressed in this environment while they thrived just a few feet away. It is likely that the salt concentrations are high in some of the low lying areas and that the rainfall is sporadic.

3.6.7 Waiawa Unit of the Pearl Harbor National Wildlife Refuge

In 1970, the State of Hawaii (in cooperation with the U.S. Navy), designated a brackish pond and marsh on the northwest corner of the peninsula as mitigation for the loss of stilt habitat during the construction of the reef runway at Honolulu Airport. Dikes, pumps, and fencing were installed and the Waiawa Unit of the Pearl Harbor National Wildlife Refuge (NWR) was established by the U.S. Fish and Wildlife Service (USFWS) in 1976. This wetland is located over a portion of the former Loko Kuhia Loko fishpond. Coots, stilts, ducks, cattle egrets (*Bulbucus ibis*) and migratory waterbirds were numerous on all visits past this marsh. Mr. Michael Silbernagle, USFWS refuge manager escorted us through the refuge on 13 August 1999.

The Waiawa unit is separated into two ponds. The northern pond is larger and deeper. This pond has islands of makai and knotgrass. There are also large stands of pickleweed

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on the edges accompanied by Indian fleabane and cattails. Koa haole is common in the upper areas.

The southern pond is more heavily managed and had a much greater number of stilt. Previous visits also showed a higher concentration of coots. Mike explained that this pond is closer to the ocean and has a higher salinity. The islands are covered primarily with California grass with the edges dominated by *makai* and knotgrass.

The water levels are carefully controlled by pumping water. The water is used to drown vegetation and also to optimize waterbird habitat for the endangered Hawaiian stilt. If water levels are shallow enough, the stilt and other wading birds are able to use the pond as a loafing or foraging area. In natural conditions, this type of shallow water would be colonized by mangrove, pickleweed, or other aggressive vegetation and be unusable by waterbirds. The pump station is located west of the perimeter berm near the west corner of the refuge at the north pond. The water is pumped to both ponds near the west end of the interior dividing berm

The shoreline surrounding the refuge are monotypic mangrove forest. There is a patch of pickleweed located on the outside of the refuge near the intersection of the perimeter and the dividing berms. Indian fleabane, *kiawe*, and *milo* are also found in the area.

3.6.8 Agricultural wetlands adjacent and north of the bicycle path

A Chevron crew was installing a new pipeline and excavated a trench near the bike path. The water surface was within 10 inches of the surface and the soil was very black, wet, and clearly hydric. Vegetation was primarily pickleweed with Indian fleabane. The strips with hydric vegetation next to the bicycle path in this area are considered wetlands.

The ponds to the north next to the bike path were also field checked. These ponds are on privately controlled property and thus no attempt was made to verify ponds past the first set nearest the bicycle path. Cattail, California grass, Indian fleabane, sourbush, bulrush, water hyssop, umbrella sedge, primrose willow and water lilies (*Nymphaea sp.*) were all seen. In the pond containing water lilies, a pair of moorhen and a single coot were observed foraging. Surface water was evident in several of the ponds.

Watercress (*Nasturtium microphyllum*) was seen from afar in some of the interior ponds. Agricultural use helps to preserve wetlands from being filled and from invasion of upland vegetation. The agricultural fields in the Waiawa floodplain provide a large portion of the remaining freshwater wetlands in the Pearl Harbor region.

The stream outlet west of the NWR contained duckweed, California grass, water hyacinth Indian fleabane, and mangrove. The areas within the stream are considered wetlands.

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Figure 27 below is a photograph of the wetlands adjacent and south of the bicycle path. HECO's Waiau power plant is in the back left. Taro and watercress were seen in these ponds.

Figure 27 - Agricultural fields at Pearl City Peninsula. Wetlands #2100107256 - 2100107267

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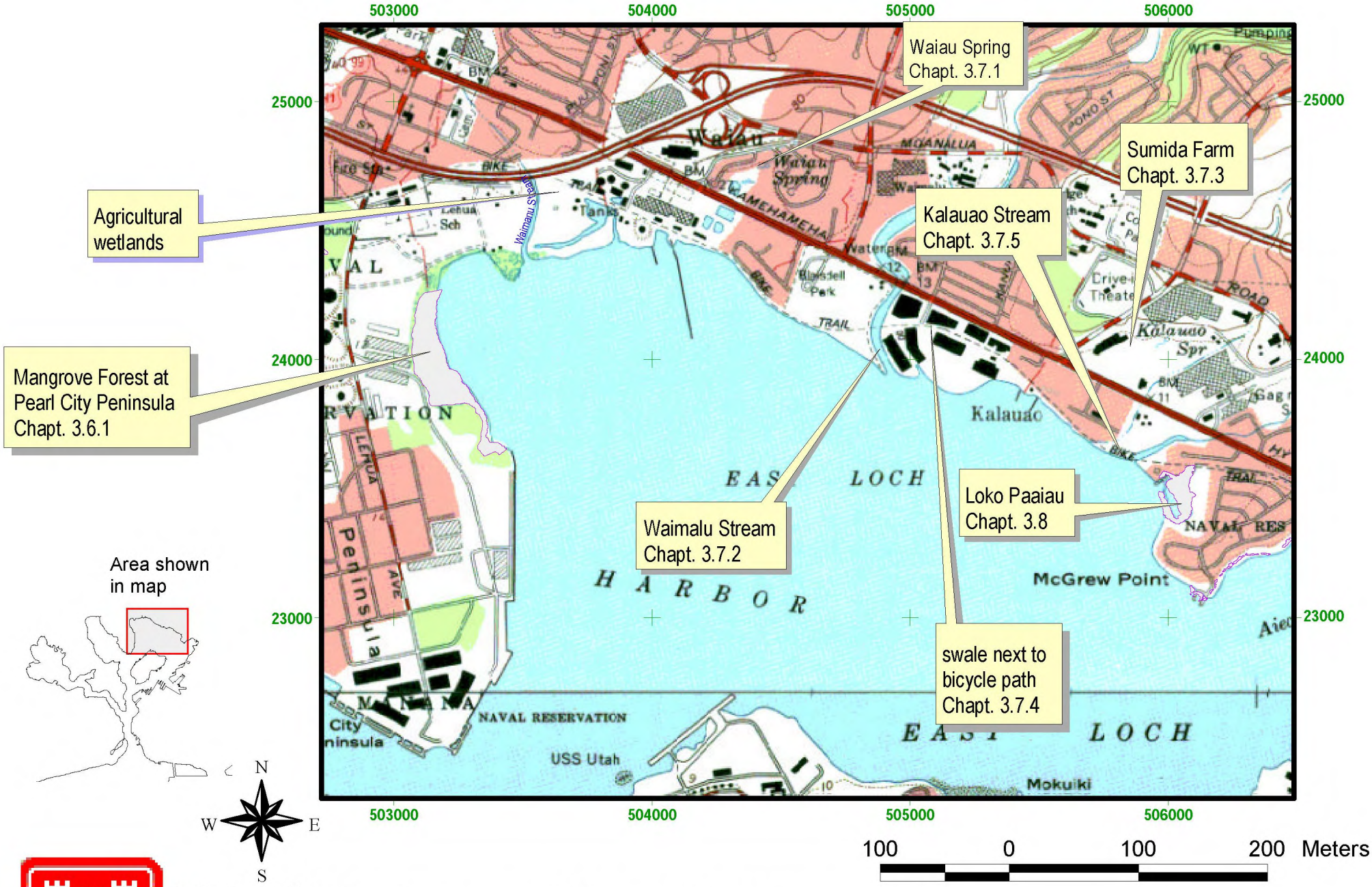

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Figure 28 - Segment 7

Waimanu Stream to Loko Paaiau

Wetlands of Pearl Harbor

AR00044245

3.7 Segment 7 - Waimanu Stream to West edge of Loko Paaiau Fishpond (East Loch Shoreline I)

3.7.1 Waiau Spring

This wetland in Waiau is bounded by residential homes along Kuleana Place, Kaulike Drive, Kamehameha Highway, and Zippy's restaurant (Figure 29). The Waiau wetland is drained by three CMP arch culverts beneath Kamehemeha Highway which empties into an open channel that crosses the east side of the Waiau power plant parcel before entering East Loch. An aquatic plant (*Vallisneria americana*, Figure 30) covers a portion of the pond near the outlet.

Figure 30 - *Vallisneria americana* found near outlet of wetland near Kamehmeha Highway.

The lower portion of this wetland is one to two feet deep and covered with water hyacinths. There were also primrose willow and umbrella sedge at the edges of the wetland. The upland edges of the wetland are cultivated with various crops such as banana, eggplant, sweet potato, and squash. Central portions of the marsh are covered with California grass. Other vegetation observed included *koa haole*, *honohono*, *ung choi* (*Ipomoea aquatica*), and *kaluha* (*Kyllinga brevifolia)*.

During the visit, we came across a farmer who had collected about a gallon of small clams. We also noted small fish traps. The *Vallisneria* patch was noted near a makeshift shelter and pier so it is possible that this patch is being cultivated for consumption.

This wetland is different from most of the wetlands we surveyed in Pearl Harbor in that it is primarily spring fed, and has a relatively deep depth when compared to other wetlands. The water is clear and this is one of the larger remaining bodies of fresh water in a natural setting adjacent to Pearl Harbor. Considering the proximity to a major roadway, and residential and commercial activities, it is still relatively secluded and aesthetically pleasing.

3.7.2 Waimalu Stream

The edges of Waimalu Stream are colonized by American Mangrove from its mouth up to the Kamehameha Highway bridge. The west side of the park is adjacent to a City and County baseyard and the Neal Blaisdell park. There are several large

Figure 31 - Waimalu Stream. View from Kamehameha Highway looking downstream towards bicycle path.

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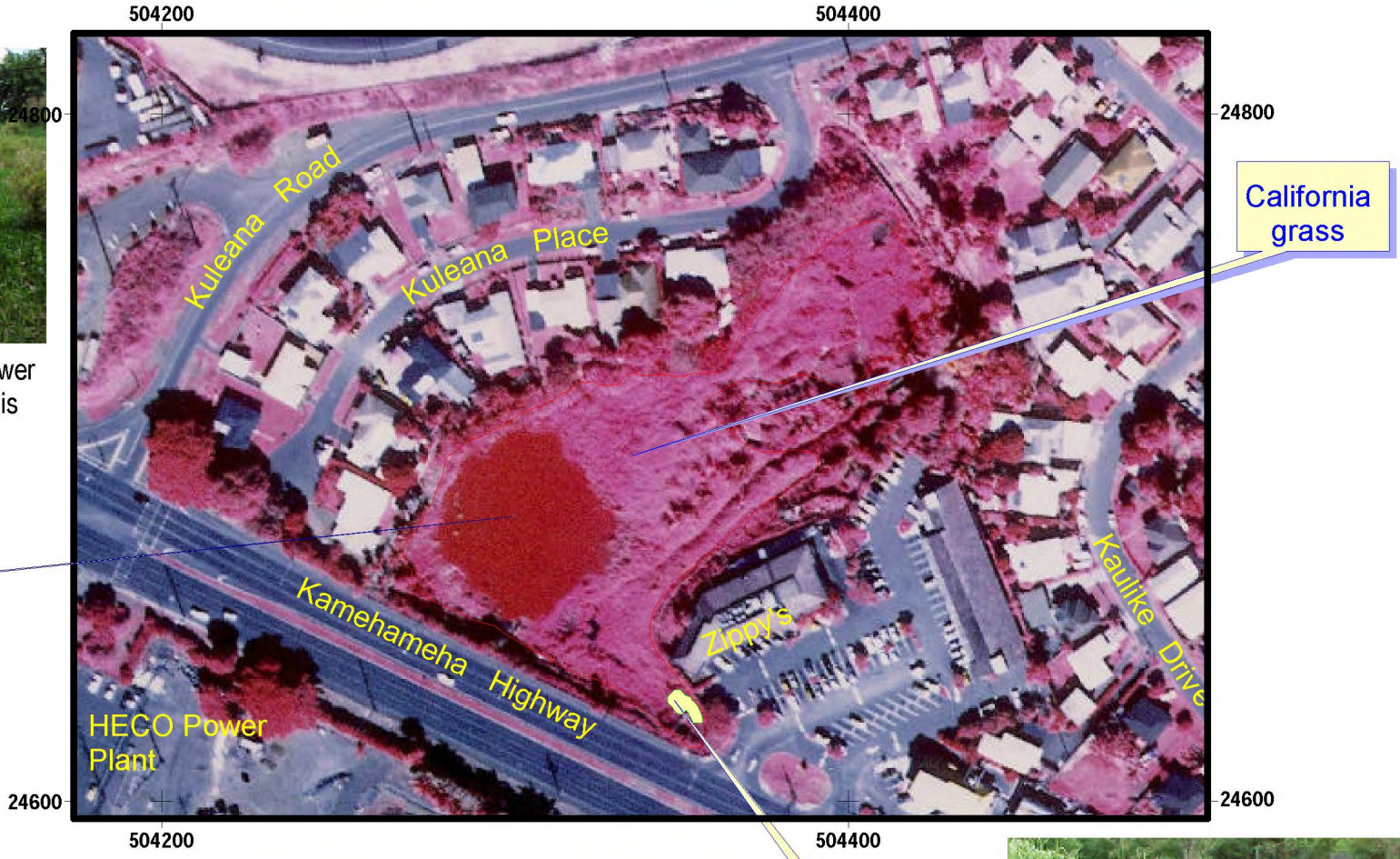
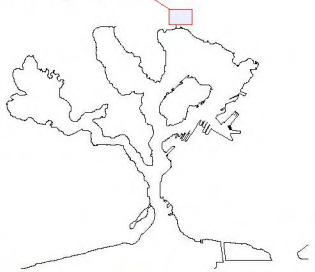
Water hyacinths dominate the lower section of the marsh. Upstream is California grass.



Area shown in photograph



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The photograph on the right is near the spring outlet beneath Kamehameha Highway. This is the area containing Vallisneria americana

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Honolulu District

Figure 29 - Waiau Wetland

See Chapter 3.7.1

Wetlands of Pearl Harbor

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kiawe trees along the shoreline with a row of mangroves in front of them. On the east side of the stream, there is more plant diversity with Christmas berry, pickleweed, *milo, koa haole*, Indian fleabane and American mangrove. Upstream of Kamehameha Highway, the channel is lined with concrete.

A large patch of pickleweed has colonized the mudflat on the delta formed at the mouth of Waimalu Stream (Figure 32). Indian fleabane, *kiawe*, *milo*, American mangrove, and California grass also occur at edges of this patch

Figure 32 - Batis field at mouth of Waimalu Stream. Wetland #2100107140

3.7.3 Sumida Farm

Nestled between Pearl Ridge and Kamehameha Highway is the Sumida Farm (Figure 33) which cultivates watercress (*Nasturtium microphyllum*). The farm is in active production and is a living reminder of the agricultural activities that once dominated this section of Pearl Harbor. There are several springs which feed the pond and a pump on the lower feeds an irrigation system which sprays the watercress several times a day. Aside from watercress, wetland species includes barnyard grass (*Echinocloa crus-galli*), Mexican sprangletop, and *Cyperus polystachyos*. Other species in the area include banana, weeping willow, Bermuda grass, guinea grass, virgate mimosa (*Desmanthus pernambucanus)* and *Sonchus oleraceus.*

3.7.4 Drainage Ditch between Bicycle Path and Harbor Center

This ditch parallels the bicycle path, is colonized by *Batis maritima* and contains tilapia (Figure 34). Water is permanent in wetland #2100107152.

Figure 34 - Harbor Center is to the right of the ditch.

3.7.5 Kalauao Stream

Like all of the other streams in this segment, Kalauao Stream is colonized by American mangrove up to the Kamehameha Highway bridge. Homes are on the east side of the stream while the Pearl Kai Shopping Center is located to the west. Mangroves have out competed most of the other species along the banks of Kalauao Stream. Other species near the east bank include African tulip and mango.

The mouth of Kalauao Stream is choked with American mangrove on both sides and the mangrove reaches up to Kamehameha Highway. A seawall at tmk 1-9-8-015:057 keeps

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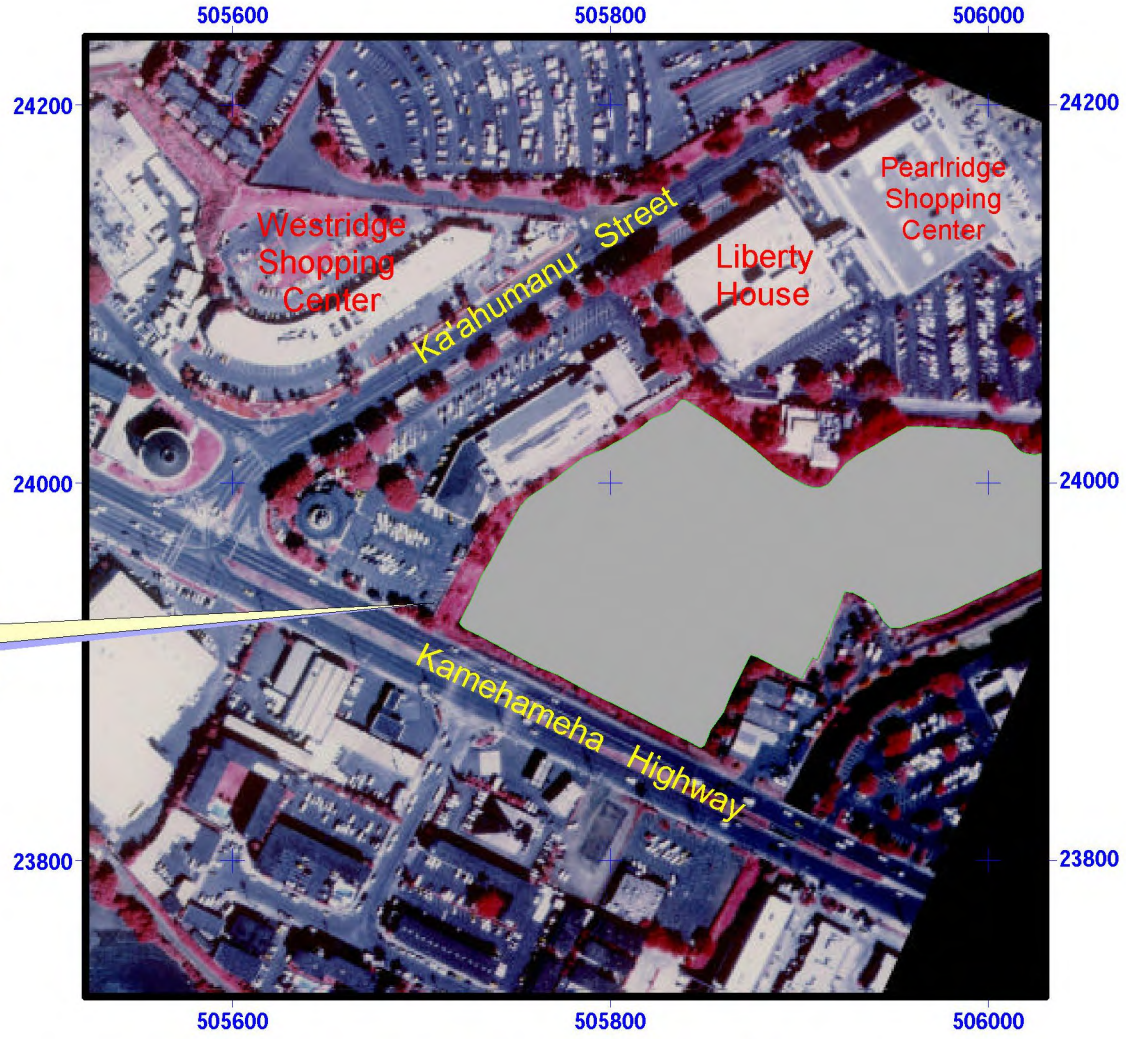
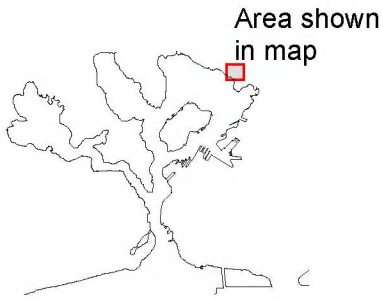
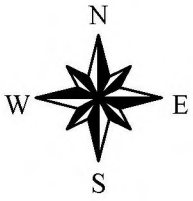
View from the Anna Miller Restaurant parking lot.

Pearl Harbor Wetland Delineation Mapping Project
Various Sites, 24 August 1999





Aerial photograph by Air Survey Hawaii, 1-20-91



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Honolulu District

Figure 33 - Sumida Farm, Aiea

Wetlands of Pearl Harbor

the mangroves from extending to Loko Paaiau fishpond. This seawall was authorized by Department of the Army permit PODCO 1401-S.

A second stream cuts through Pearl Ridge Shopping Center and adjacent to Sumida Farm and the west side of Pearl Kai Shopping Center. Wetland vegetation in this area includes *honohono, Echinocloa crus-galli, Paspalum conjugatum, Cyperus polystachyos,* California grass, umbrella sedge, and mangrove.

Department of the Army permit number PODCO 1987 was issued to the developer of the Pearl Kai Shopping Center for the placement of fill in the wetlands. To account for the flood storage wetland function, the shopping center's building closest to the stream was built on posts. As additional mitigation for placing fill in the wetland, mangroves were removed and a wetland pond and nesting island were constructed (Figure 35). Wetland vegetation at the site area includes *Cyperus difformis, Paspalum conjugatum, Cyperus polystachyos,* water hyssop, California grass, umbrella sedge, and mangrove. Two large dogs were seen on or near the site in two separate visits.

Figure 35 - Pearl Kai Shopping Center mitigation site. Bicycle path is behind the fence. Wetland #2100107042

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3.8 Segment 8 - West edge of Loko Paaiau Fishpond to East end of housing area (McGrew Point)

The main cartographic features are shown in figure 36. McGrew Point Naval housing area is bounded by Aiea Bay State Recreation Area to the east, Kamehameha Highway and the bicycle trail to the north, and Loko Paaiau to the west. Located on a headland, the property slopes downward towards the east, south and west. There are no wetlands in the interior of the property. Wetlands are located along the shoreline. Kalauao Stream to the west and Aiea Stream to the east are the closest streams.

The most significant wetland feature is the mangrove-choked Loko Paaiau Fishpond on the northwestern boundary of the property. The interior of Loko Paaiau is deep enough to prevent mangrove encroachment. However, the edges are choked with mangrove which helps to buffer the area from McGrew Point Housing Area and creates a secluded area for fish. There were no waterbirds observed during several visits to the fishpond. Patches of monotypic stands of pickleweed occur along the shoreline and at the opening of the fishpond. However, American mangrove is the predominant vegetation in and around Loko Paaiau. Towards the edges *hau*, Guinea grass, Indian fleabane, *koa haole*, *kiawe*, and *'opiuma* (*Pithecellobium dulce*) are common. A sample point was taken on the spit of land forming the seaward boundary of the fishpond. This area was completely covered by American mangrove.

Based on the presence of all three wetland criteria, the area surrounding Loko Paaiau is considered a wetland. There is a fence running from the ocean to the bicycle path at the east boundary of McGrew Point. There is fill material outside of the McGrew Point boundary within the fence and there are non wetland plants such as *'opiuma*, date, and Christmas berry. Thus the tree line is a conservative estimate of wetlands. If this area is to be developed at a later date a more refined wetland delineation may be warranted.

According to Sterling and Summers (1978), terraces irrigated from Kalauao Stream fed into Loko Paiau. There are no longer any terraces as the area was modified for sugar cane and is now heavily developed for housing. There is a which is used as a conservative wetland delineation boundary.

Outside of Loko Paaiau, the soccer field and recreation facilities are situated in a low area which drains the McGrew Point Housing area. The drainageway terminates at a flat area before reaching the shoreline. This area is colonized by pickleweed and was mowed on at least two occasions during the several visits made to the area. Like Ford Island, the pickleweed and mangroves colonize the area due to the lack of competition from other species.

There is a drainage ditch that exits seaward of the soccer field and adjacent to a portion of the fence. This area contains water hyssop and there is an open water connection. This area is fenced and also considered a wetland. The field is low in this vicinity and the

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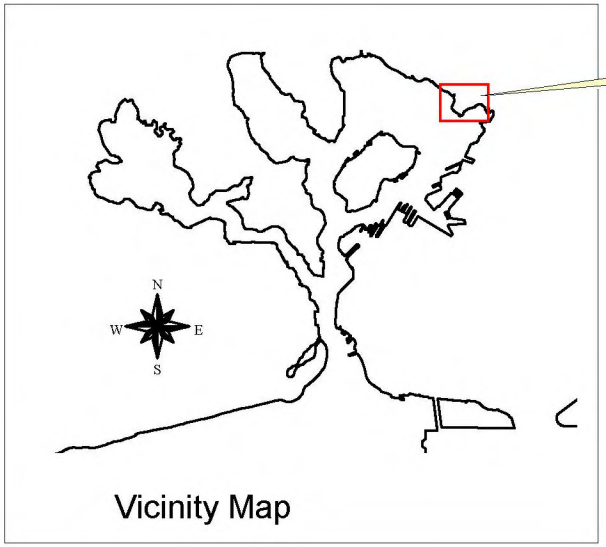
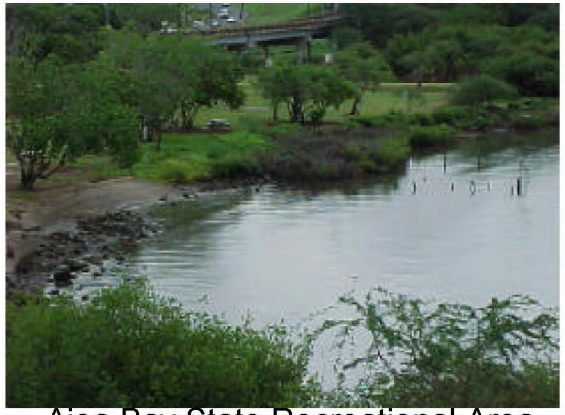


McGrew Point Housing Area



Aiea Bay State Recreational Area

Kalauao Stream

Aiea Bay State Recreation Area

Loko Pa'aiau Fishpond

Aiea Stream

McGrew Point Housing Area

East Loch Shoreline at Loko Pa'aiau

Aiea Stream below Moanalua Road

U.S. Army Corps of Engineers
Honolulu District

Figure 36 - Vicinity Map for McGrew Point Housing Area and East Loch Shoreline at Aiea Bay

ground was saturated at the time of visit. If the field was not maintained, it is likely that this area could revert to a wetland.

At the shoreline on the housing side of the fence is a low lying area that is covered with pickleweed. This area was mowed between the two visits and the area is likely to be maintained. Based on the hydrology and a soil sample taken at this site, the area is a wetland

Walking in a counterclockwise direction towards the Aiea Bay State Recreational Area, the shoreline is abrupt as the elevation rises and there is a steep slope towards the shore. A fence is offset inland from the top of bank and extends all the way to the access road to the State recreational area. There is a large stand of night blooming cereus *(Hylocereus undatus*) on the east side of the peninsula. Other upland vegetation includes sourgrass (*Digitaria insularis*), swollen finger grass, and spurge (*Chamaesyce hirta*). There are several pockets of wetlands on the bottom of the slope caused by the colonization of American mangrove. The mangrove does a good job in protecting the shoreline from erosion but also prevents shoreline access. Shoreward of the mangrove are *milo, kiawe,* and Indian fleabane. Almost all of the wetlands are outside of the fence and thus it is unlikely that there will be any Naval development in these areas in the near future.

The topography rises past this flat area creating a bank extending from the shoreline to the housing area. Generally, the seaward face of McGrew Point is clear of mangrove. Along the Aiea Bay shoreline, there are several large stands of mangroves. Several points were dug in this area. In general, the shoreline is very cobbly with a lot of smooth rounded stones. The stones are gray and appear to be chunks of clay which are well rounded and fractures very easily. Some of the clay near the shoreline is mixed in with the soils to give an appearance of gleying. Most of the mangrove areas are tidally influenced or at the very least, periodically inundated. The debris often extends beyond the mangrove. The mangrove areas meet the three criteria for wetlands.

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3.9 Segment 9 East Loch Shoreline II

Segment 9 extends from the east side of McGrew Point to the north side of Halawa Stream. This area includes the Aiea Bay State Recreation Area.

The shoreline between McGrew Point and the Admiral's boat house were also checked. The shoreline has a lot of American mangrove concentrated at the mouth of Aiea Stream and headed towards the boat house. The State was actively trimming the mangrove and *milo* along the shoreline at the recreational area to maintain a view plane while still leaving the root substructure which serves to protect the shoreline. Photos were taken from the overpass at Moanalua Road.

3.10 Segment 10 - South side of Halawa Stream to South Avenue

Halawa Stream

Halawa Stream consists of a North Branch and a South Branch. The headwaters of the North Branch is located approximately 7 miles upstream from its outlet while the South Branch headwaters is located just over 3.1 miles from its terminus (COE headwater study). Due to access constraints, we did not proceed more than 200 feet upstream of Kamehameha Highway along the east bannk of Halawa Stream. If future work is planned, this area should be rechecked for wetlands.

The stretch of Halawa Stream that pertains to this study is tidally influenced and runs from the Salt Lake Boulevard bridge to the outlet at the Arizona Memorial visitors center. There are three other crossings downstream of Salt Lake Boulevard. The first is the bridge carrying two lanes of west bound traffic on Kamehameha Highway which is followed by a second bridge carrying two lanes of east bound traffic on Kamehameha Highway. During the field investigations for this study, a State Department of Transportation Highways Division survey crew was performing a topographic survey for a replacement bridge. The third crossing is down stream from the Kamehameha Highway bridge and carries the fuel pipeline and pedestrians.

Halawa Stream has been dredged in 1965 (VTN, 1977) and at least twice in the last 25 years. American mangrove has colonized both sides of the shoreline in the vicinity of Kamehameha Highway. People were crabbing and fishing in the stream at the time of the survey and a variety of fish including mullet, tilapia, and a large puffer fish (*Diodon holocanthus*) were observed. Further upstream Indian fleabane was more dominant.

Mangroves are listed as obligate wetland plants but of themselves do not constitute a regulatory wetland. Mangroves can be found in other waters of the U.S. including streams, rivers, embayments and shorelines. Their seedlings drop from the tree and float to calm, shallow water where they become established. In areas where there is a buildup of sediment caused by mangrove encroachment, the stream or shoreline may change from

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a waterway to a wetland. This is the case in the area between the bridges over Kamehameha Highway and the pipeline crossing. Sample points were taken on the east side of the stream as shown. The soil had low chroma and exhibited indications of gleying.

Shipyard

Based upon a request from PACNAVFACENGCOM, we visited the shoreline from the pier near Building 478 to pier K12. The shoreline is presently covered by construction debris with *milo* occurring in the area. The top of the slope was 4-8 feet higher than the water level at the time of the visit. Because most of the area is paved or hardened, wetland hydrology and soils are not present thus these areas are not considered wetlands.

The remainder of the shoreline up to South Avenue appears to be hardened with the exception of portions of the Hospital Point Housing area. We visited this site and found that the landward portions of the area drops down 2-4 feet to a coral and sand substrate. Mangrove and *milo* exist in relatively sparse clumps. This area and the shipyard area as a whole, does not contain any jurisdictional wetlands.

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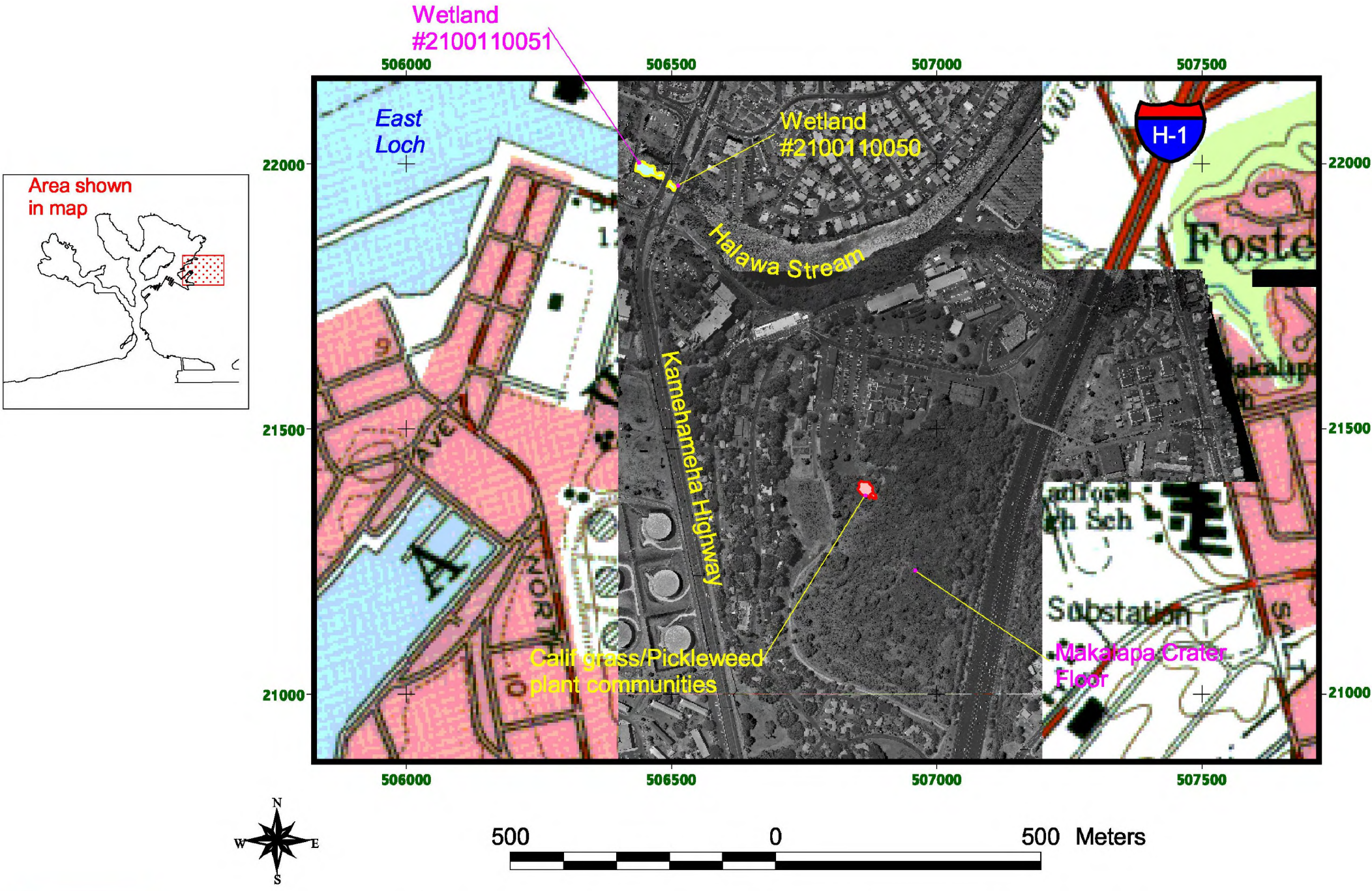

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Figure 37 - Makalapa Crater

Wetlands of Pearl Harbor

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3.11 Segment 11 - Makalapa Crater

To the east of Pearl Harbor are a cluster of overlapping tuff cones which includes Aliamanu, Makalapa, and Salt Lake Craters. The cones blocked the former paths of Moanalua and Halawa Streams and forced wide detours to the sea (Stearns, 1966). The scope of this wetland delineation was limited to Makalapa Naval Reservation which is located within Makalapa crater. As noted in *Sites of Oahu* (Sterling and Summers, 1978), the crater was formerly used as a freshwater fishpond. From 1935 to 1946, the crater was used for dredged material disposal from dredging at Pearl Harbor and was filled with 30 to 40 feet of sediment (VTN Pacific, 1977). In 1957, the crater was noted as being overgrown and swampy. The U.S. Fish and Wildlife Service's National Wetland Inventory map notes a wetland in this area.

The Makalapa Naval Reservation is bounded by the H-1 freeway, Radford Drive, Kamehameha Highway, Moanalua Stream and the access road off of Salt Lake Boulevard to the back gate (see figure 37). Most of the areas are developed for residential housing or Naval operations. The developed areas are on slopes which are predominantly clear of any signs of wetlands.

We drove through most of Makalapa Naval Reservation and walked through the area of the former crater floor. When we visited the site, it was filled with Guinea grass, *koa haole, kiawe*, Chinese violet, ivy gourd, castor bean, Indian fleabane, Fosberg's fleabane, sourbush and other upland species. There was a lot of demolition type debris (asphalt, broken concrete, old machinery, old fill, broken pipes, etc.). Behind the Bachelors Enlisted Quarters and buildings 348 and 380 is what appears to be a maintenance shop. Behind this area is a patch of pickleweed and California grass (Figure 38). Because these are wetland species and the vegetation was much greener than other areas in the crater, we dug a hole to see if there were soil or hydrologic indicators. The soil was a fine grained brown sandy clay that was very dry. The roots of the plants exhibited no oxidation and there was no mottling of the soil. Since there were no hydric soil indicators, it was concluded that this was a remnant patch of vegetation that at one time, may have been part of a larger wetland that no longer exists. There were no debris lines saturated soil or other evidence of wetland hydrology. This area is not considered a wetland.

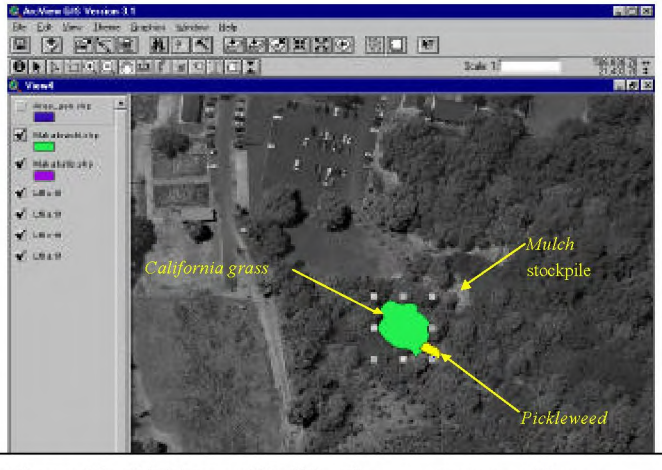

Figure 38 - Pickleweed/California grass communities at Makalapa Crater.

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Also of interest is a stream which enters from a box culvert beneath the freeway and runs through the eastern corner of the property before exiting beneath Radford Drive (Figure 39). The water was flowing and the stream was populated with mosquito fish indicating continual flow. This is considered a water of the U.S., but not considered a wetland. Any plans for placement of fill in this area should be coordinated with the Corps of Engineer's Honolulu Engineer District Regulatory Branch at 438-9258 to ensure that permit requirements are addressed before any fill is placed.

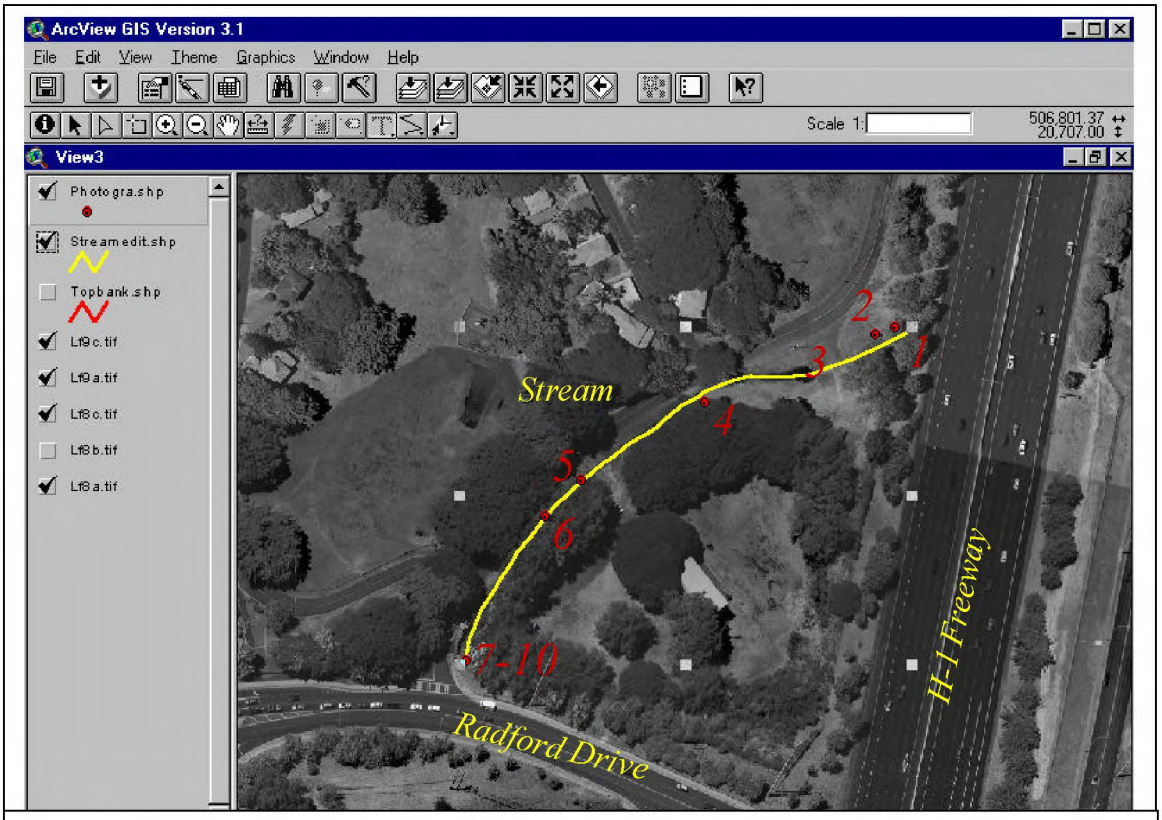

Figure 39 - Stream at Makalapa Crater. See Appendix B for photographs.

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Segment 12 - Ford Island

Mokuumeume Island, more commonly known as Ford Island, is a low, flat island located at the confluence of East and Middle Lochs. Due to the flatness of the island and low rainfall, there were no wetlands seen in the interior of the island. However, the shoreline has many plants that are commonly found in wetlands such as pickleweed, American Mangrove, Indian fleabane and *milo*. Investigation of these areas found that hydric soils and hydrology indicators were lacking and thus, wetlands do not presently exist at Ford Island.

The most prominent structure on the island is the 4,672-foot-long fixed bridge with a floating, retractable 930-foot-long pontoon (see figure 40). The Admiral Clarey bridge connects the main portion of Oahu to Ford Island and was opened in 1998. An engineering landmark, the structure enables vehicular traffic and allow the development of Ford Island. Prior to the bridge, a ferry system was used to provide access to the island.

The shoreline of this island has been heavily altered due to World War II activities. Numerous vessels including the U.S.S. Utah, the U.S.S. Arizona, and the U.S.S. Tennessee were sunk near the shoreline of Ford Island. Seaplane ramps, bulkheads, piers, shoreline protection structures, and demolition/construction debris can be found along Ford Island's shores. From the south tip of the island to Pier F-5 (Missouri home port), the shoreline is heavily developed and there is very little vegetation in this segment. To characterize the shoreline and to confirm whether wetlands exist, the authors walked the remainder of the shoreline and mapped the shoreline type using a Trimble Pro XRS

Figure 40 - Admiral Clarey bridge and U.S.S. Arizona memorial.

Global Positioning System (GPS) unit. Figure 41 shows the shoreline segments. To make better sense of this data, the shoreline information was converted into an ArcView

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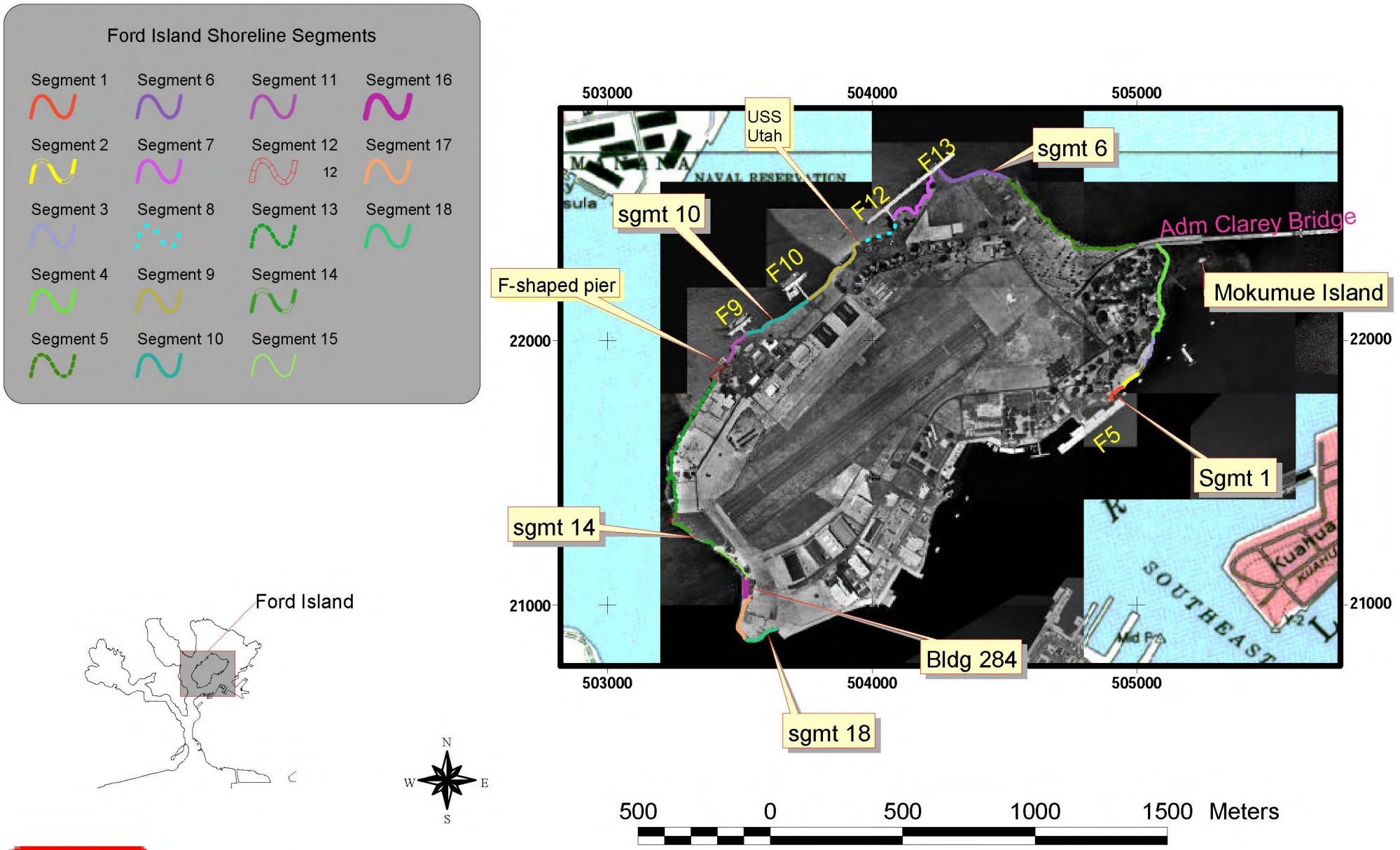

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Figure 41 - Ford Island Shoreline Types

shapefile and photographs were hotlinked to the view. The following paragraphs describe the various shoreline segments.

The Ford Island shoreline was divided into eighteen segments which are described below:

Segment 1 North of Pier F-5, there are several vacant homes. In this area, the shoreline is an eroded limestone face approximately 6-8 feet high. Shoreline vegetation includes *milo*, coconut, *koa haole*, and *kiawe*. Construction debris including slabs of concrete, has been placed along the shoreline as erosion protection (Figure 42).

Figure 42 Segment 1

Segment 2 From Pier F-5 north to the Arizona memorial, there is a low level area one to two feet above water level. A thin layer (one to two inches) of red soil has been placed atop old fill and is grassed in the upper areas (Figure 43). The area closest to the shore appears to be infrequently flooded as evidenced by salt crystals and the lack of vegetation. There are no trees and pickleweed, *milo,* and *kiawe* are the dominant vegetation along the shoreline. The soils are fill material and were very dry and hard during the visits. Thus this area is not a wetland.

Figure 43 Segment 2

Segment 3 The construction debris continues through this section past the pickleweed area, to an area with trees and shrubs including Fosberg's fleabane, *milo*, and *kiawe*.

Segment 4 The shoreline in this segment (Figure 44) intersects with the base of the bank which extends from the officers' quarters to the Ford Island Bridge. This is the highest point on the island, which has eroded due to its exposure to the prevailing offshore winds. The shoreline is primarily coralline in this area and the steep slope precludes the formation of wetland conditions. Vegetation includes sourbush, *koa haole, kiawe,* banyan, and coconut. The shoreline here is similar from this point to the bridge.

Figure 44 - Segment 4

Figure 45 - Segment 5

Segment 5 This segment begins on the west approach of the bridge, past the golf course. A coated chain link fence

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begins at the seaward boundary of the golf course and extends to Pier F13. The primary shoreline vegetation includes *milo*, pickleweed, and *kiawe*. The higher parts of the shoreline are approximately 15-20 feet above the water. Generally, the shoreline is exposed to fetch waves and shows signs of erosion. The toe of the banks are protected by construction debris. In the area near the driving range and the temporary scaffolding platform, there is a flat accreted area covered 95% by pickleweed with American mangrove and *milo* at the edges. The flat area appears to have been created by an old rusted out barge at the top of the area which formed a tombolo. The sheltering from the predominant winds has allowed the area to accrete. This is the only stretch of shoreline on the island which appears to be accreting. We dug an 18-inch-deep hole in the middle of the pickleweed patch. There was no moisture and the material consisted primarily of shells and roots with very little sand or soil. The shoreline was similarly rocky and also contained a lot of shells. Due to the lack of hydrology and soil, this area was determined not to contain wetlands.

Segment 6 This area has large stands of pickleweed amid the construction debris and extends to Pier F13.

Segment 7 The areas between Piers F12 and F13 appears to be filled by coralline material and concrete rubble (Figure 46). The land is level and approximately 6-10 feet above the water surface. Concrete rubble is exposed on the very steep bank. Judging from the monkeypod, and *kiawe*, it appears that this area was built up and leveled many years ago. Mangrove and pickleweed are abundant on the shoreline. *Milo* are interspersed primarily near the top of the banks. The vegetation is trimmed and maintained. Similar to the previous segment, this area does not meet the 1987 Corps of Engineers Wetland Delineation Manual wetland criteria due to the lack of hydrology and soils. Like a lot of Ford Island, the hydric vegetation thrives because it has little or no competition in the low rainfall, saline area.

Figure 46 - Segment 7

Segment 8 Between Pier F12 and the U.S.S. Utah, the shoreline vegetation is primarily pickleweed. There is the remnant of an old pier, a short bulkhead and construction debris in the area. Also of interest are the mangroves growing in the Utah.

Figure 47 - Segment 8

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Segment 9 Between the U.S.S. Utah and Pier F10, the vegetation is primarily *milo*, and *kiawe* (Figure 48). There is heavy construction debris along the shoreline.

Figure 48 - Segment 9

Segment 10 Between Pier F10 and F9, the shore is protected by construction debris.

Segment 11 Between Pier F9 and the F-shape pier, there is an elevation raise in the shoreline. This area also has construction debris (Figure 49). A rock and concrete vertical seawall (Figure 50) also protects the shoreline both upstream and downstream of the F-shaped pier.

Figure 49 (Left)

Figure 50 (Right)

Segment 12 The vertical seawall meets up with a steel sheet pile wall that continues to a 90° turn and proceeds to a 24" x36" concrete culvert with wing walls.

Figure 51 - Segment 12

Segment 13 The elevation of the shoreline tapers down following the wing wall to a gentle slope. The construction debris in this area is older and finer. This stretch of shoreline includes the four seaplane ramps. Dense stands of *kiawe* occupy the shore area. This area has sand and gravel and one of the most aesthetically pleasing natural shoreline on the island. This segment ends at the end of the runway. At this point, there is another stone and mortar vertical seawall.

Segment 14 A revetment constructed out of construction debris extends from the seawall at the end of the runway to the final seaplane ramp (Figure 52).

Figure 52 - Segment 14

Segment 15 This is the stretch between the seaplane ramp and

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Building 284. The shoreline is gentle and there is gravel and sand. Steel sheet pile from the remnants of an old pier or landing break this section into two.

Figure 53 Segment 15

Segment 16 The area beneath Building 284 is smooth concrete, similar to the seaplane landing areas along the south face of the island. The piers supporting the deck at Building 284 is in extremely bad shape with the rebar exposed in most of the concrete piles (Figure 54).

Figure 54 - Segment 16

Segment 17 A continuation of the concrete seaplane ramp (Figure 55).

Figure 55 - Segment 17

Segment 18 The last natural piece of shoreline between the seaplane ramps near the East channel. This area has a gravel shoreline which is vegetated by *kiawe* and pickleweed (Figure 56).

Figure 56 - Segment 18

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Chapter 4 - Summary and Conclusions

4.1 Overall Summary of the Wetlands of Pearl Harbor

In the past 150 years or so, Hawaiian society, economy, and environment has undergone tremendous changes. These changes have impacted the quantity and quality of wetlands in ways that were never foreseen. But all things considered, there is still a variety of wetlands remaining in the Pearl Harbor area and it would be prudent to consider their value in all planning processes. Table 3 below is a summary of wetland acreages in the Pearl Harbor area.

At the time that this report was completed, a total of 456.41 acres of wetlands were found in the Pearl Harbor area. The final total should be higher when taking into account additional wetlands in the Waiawa floodplain and additional watercress area in Aiea. These areas are outside of the orthophotograph coverage. Both of these areas are in active agricultural use which is a major reason why these wetlands exist in as good a shape as they are in today.

Table 3 - Types of Wetlands in Pearl Harbor

	Mangrove	Other Coastal	Stream	Other fresh water	Totals
	(acres)	(acres)	(acres)	(acres)	(acres)
Navy Property	115.66	4.71	0.35	6.24	126.96
Non-Navy Property	172.74	77.28	13.42	66.01	329.45
Totals	288.40	81.99	13.77	72.25	456.41
	(acres)	(acres)	(acres)	(acres)	(acres)
East Loch	38.82	3.61	18.87	1.76	63.06
Middle Loch	63.75	23.32	22.80	6.40	116.27
West Loch	185.82	55.07	30.58	5.61	277.08
Totals	288.39	82.00	72.25	13.77	456.41

In general, the freshwater wetlands like those found in Waiau, Pearl City Peninsula, and the mitigation site at Kolea Cove's property are undergoing a natural decline as aggressive alien plant species encroach into the wetland and shrink the boundaries. This is typical of formerly farmed wetland areas after they are abandoned. A similar example is the Niumalu Marsh area on Kauai. A spring fed marsh, this wetland was once farmed in taro and later converted to rice. Photographs in the early 1900's show the area as being clear of obtrusive vegetation. Abandoned over 50 years ago, the areas that are not farmed are now overgrown with California grass, primrose willow and *honohono*. These are the same plant species that are invading some of the aforementioned wetlands in Pearl Harbor. If nature is allowed to take its

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course, the vegetation will keep piling up and sediments will continue to be trapped in these wetlands. This cycle will lead to the conversion of wetlands to uplands. Wetland functions such as waterbird habitat and flood storage will also continue to decline.

Another concern is the mangrove colonization of mudflats and coastal areas. Since its introduction in the early 1900's, it has become the dominant vegetation in low energy coastal areas. Table 4 shows that mangroves dominate 63% of the wetlands in Pearl Harbor. Mangrove has both positive and negative aspects to it. Large forests of mangrove cover much of the Pearl Harbor shoreline. Similarly, mangroves are heavily entrenched in most of the streams including Halawa Stream, Aiea Stream, Kalauao Stream, Waimalu Stream, Waiawa Stream, and Kapakahi Stream. For the deeper and wider streams, the mangroves are not a problem. However, for the shallower and narrower streams, such as Kalauao, the mangroves are constricting the stream channels which could impact drainage conditions during periods of high flow.

On the flip side, mangroves prevent erosion of the shoreline and allow sediments to settle out of the water column. These actions help reduce the sediment load in the harbor. By trimming the mangroves, a view plane can be maintained while enjoying the benefits of shore protection. An example of this can be seen at the Aiea Bay State Recreation Area. Mangroves also provide habitat for small fish, crabs and invertebrates.

The U.S. Fish and Wildlife Refuges, Pouhala Marsh, and mitigation sites are the only areas which have the luxury of being maintained for wildlife functions. Most of the waterbirds seen during numerous field visits were in these areas which account for 14% of the wetlands in Pearl Harbor. However, quite a few stilt were seen in other areas such as the abandoned sewer treatment plant at Pearl City Peninsula, and the ponds near the West Loch golf course. Until recently, many ducks used the manmade pond at the entrance to Ewa-by-Gentry subdivision at the intersection of Kolowaka Street and Fort Weaver Road. The old sugar mill process water ponds at Waipio Peninsula have dried up and are no longer used by waterbirds. Considering the high value of the ponds during the time of the Ahuimanu Productions study in the 1970's, the loss of these ponds adversely affect the availability of suitable waterbird habitat.

Human use of wetlands are in most cases beneficial to keeping wetlands from disappearing. Farming of wetlands helps by removing unwanted vegetation, maintaining open water, providing a food source and shelter for wetland animals. Agricultural crops in the Pearl Harbor area include ung choi, taro, hasu, watercress, and aquarium plants. Englis (1993) indicated that certain agricultural sites are highly productive sites for endangered waterbirds.

Even silt basins with no intent to provide biological functions, requires management. The basins become filled with sediment and vegetation and need to be periodically cleared. The silt basin at West Loch (see chapter 3.3.1) has its own problem in that someone is stealing the fencing material. The USFWS refuges have also encountered this problem in the past.

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In recent times, the largest growth in wetlands and open water has come from golf course development while the largest decrease has come from agricultural activities. Many of the new golf courses are on lands formerly used for agricultural purposes. Golf course ponds provide habitat for waterbirds particularly during drought conditions. They also help to filter sediments and, in some cases, provide groundwater discharge. In the past decade, many golf courses with open water have been developed in the region. This includes the New Ewa Beach Golf Club, West Loch Golf Course, Hawaii Prince Golf Club, Coral Creek Golf Course, Ewa Villages Golf Course, and Waikele Golf Club.

Table 4 below compares the major uses of wetlands in the Pearl Harbor area.

Table 4 - Major Wetland Uses in Pearl Harbor

	Agriculture	Golf Course	Sediment Basin / Flood Storage	Waterbird	Sewage Treatment	Other	Total
East Loch	18.70	0.00	1.98	0.21	0.00	42.17	63.06
Middle Loch	14.29	1.37	21.39	19.51	0.00	59.71	116.27
West Loch	7.56	27.12	0.27	43.66	1.58	196.89	277.08
Total	40.55	28.49	23.64	63.38	1.58	298.77	456.41

The authors of this report are of the opinion that mitigation banking should be considered for small wetland fills where wildlife functions are important. Wetlands providing wildlife habitat require maintenance which is impractical without a long term commitment. Natural waterbird habitat in Pearl Harbor is at a premium and a small maintained wetland is much more desirable then a larger wetland without any maintenance at all.

4.2 Summary of Wetlands on Naval Properties in Pearl Harbor

Table 5 below shows the breakdown of wetlands on Naval properties. This accounts for 28% of all the wetlands in the Pearl Harbor Region.

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Table 5 - Types of Wetlands on Navy Properties in Pearl Harbor					
	Mangrove	**Other Coastal**	**Stream**	**Other fresh water**	**Total**
	(acres)	(acres)	(acres)	(acres)	(acres)
Puuloa Rifle Range	0.00	0.00	0.00	0.00	0.00
Iroquois Point Lagoon (Iroquois Housing Area)	2.86	0.00	0.00	0.00	2.86
NAVMAG Lualualei - West Loch Branch	14.74	0.00	0.00	0.00	14.74
Waipio Peninsula	36.61	0.86	0.00	0.00	37.47
Pearl City Peninsula	56.05	3.85	0.10	6.24	66.24
McGrew Point	5.27	0.00	0.00	0.00	5.27
Naval Station Pearl Harbor Complex	0.13	0.00	0.25	0.00	0.38
Makalapa Crater	0.00	0.00	0.00	0.00	0.00
Ford Island	0.00	0.00	0.00	0.00	0.00
Total	115.66	4.71	0.35	6.24	126.96

Of these areas, Puuloa Rifle Range, Naval Supply Center, Shipyard, Makalapa Crater and Ford Island do not presently have any wetlands as defined by the Corps of Engineers 1987 Wetland Delineation manual. However, there are hydric indicators present at all of these areas which could potentially be considered wetlands in the future.

Table 5 shows that the mangrove forest wetlands are the most common type of wetlands on Navy property at Iroquois Point Lagoon, NAVMAG Lualualei West Loch Branch, McGrew Point, Halawa Stream, Pearl City Peninsula and Waipio Peninsula. Pearl City Peninsula has the most variety of wetlands and the only freshwater wetland on Navy property. At 52%, Pearl City Peninsula contains the highest percentage of wetlands on Navy property followed by Waipio Peninsula (29%) and Naval Magazine Lualualei West Loch Branch (12%). The total of the remaining areas contain less than 7% of the wetlands on Navy property.

4.3 Conclusions

It has been many years since a regional wetland inventory in Hawaii of this magnitude has been undertaken. Regional inventories are necessary to understand the evolution of wetlands and cumulative impacts from wetland fills. Modern technology to improve the techniques in capturing and analyzing data have helped make the data more useful in explaining the evolvement of the wetlands of Pearl Harbor. Certainly, the U.S. Navy is to be commended in

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taking the proactive action to fund this study. It is hoped that the products derived from this study will add to the knowledge base and make it easier for planners and regulators to understand and communicate with each other in regard to actions affecting wetlands in Pearl Harbor. And for others, we hope that this data will lead to an appreciation of the wetlands of Pearl Harbor.

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